Space/Aeronautics

JUL 19 1961

THE MAGAZINE OF AEROSPACE TECHNOLOGIES

JULY 1961

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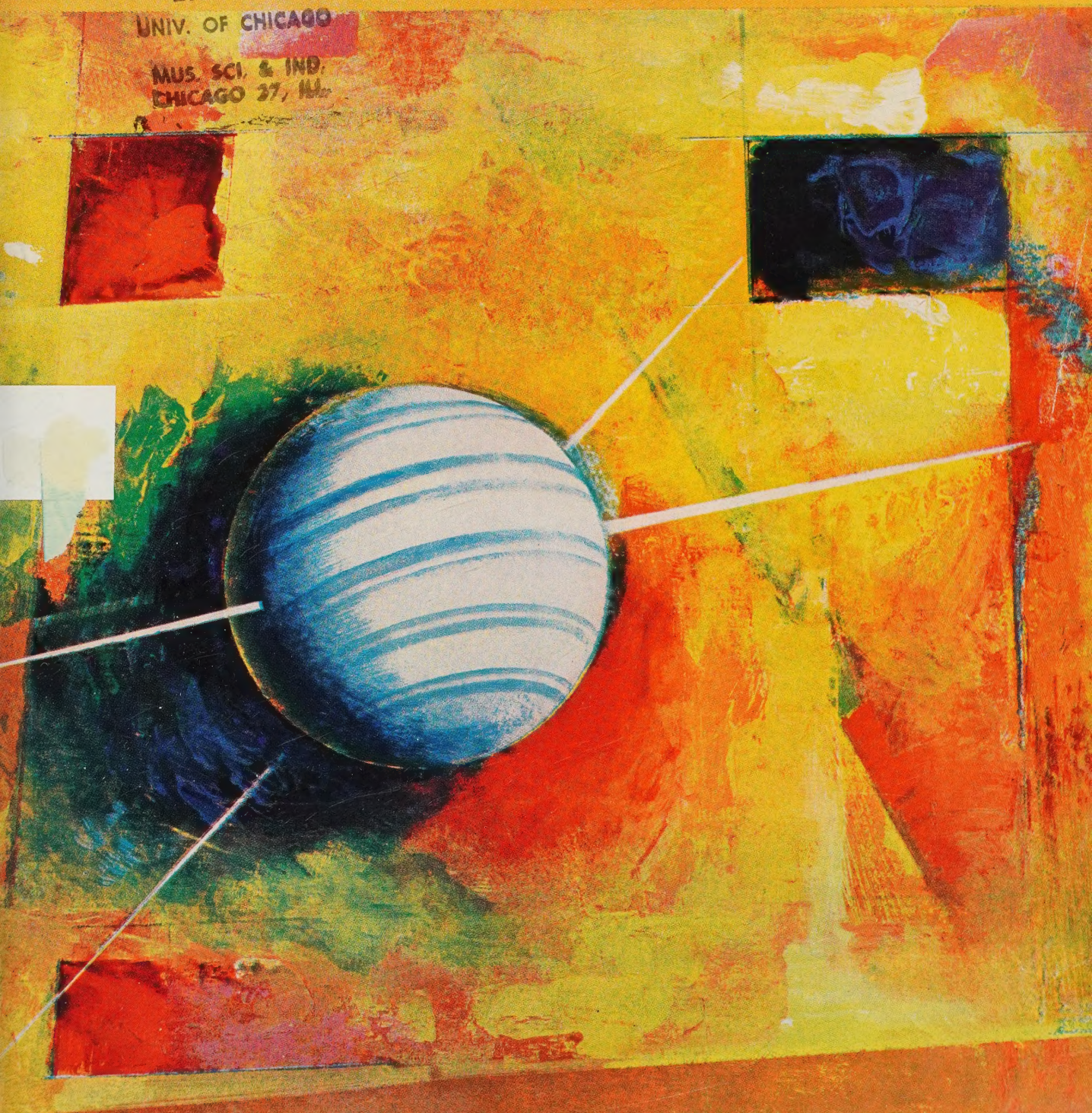

Special Report:

SPACECRAFT TEMPERATURE CONTROL

HANOVER-MAST PUBLICATION

Safety Valve FOR AN ASTRONAUT

If America's first man-carrying rocket runs into trouble, a unique Donner device will play a vital role in bringing the Astronaut safely back to earth.

Known as a "maximum altitude sensor," the all solid-state system is essentially a fixed purpose miniature analog computer housed in a magnesium case only five inches long. Installed in the capsule, it goes into action if it is necessary to abort the rocket flight before the Astronaut's escape tower is jettisoned.

What it Does

The Donner device, which was developed for McDonnell Aviation with the approval of NASA, provides programmed time delay that operates rescue devices at maximum altitude.

Under abort conditions, the maximum altitude sensor provides output information which will:

1. Energize devices for firing the explosive bolts holding the escape tower onto the top of the capsule. This allows the escape tower to separate.

2. Energize the system which causes the escape tower jettison rocket to fire. With the tower separated, barostats are armed to open parachutes and furnish the Astronaut's capsule a safe descent.

Specialists in Analog & Digital Dynamics

Donner's maximum altitude sensor is another product from a firm specializing in the manufacture of accurate fixed and general purpose analog and digital systems designed to analyze, measure, and control inputs interlocking time, acceleration, jerk, velocity, and other dynamic inputs.

If you would like more information concerning our capabilities, contact your nearby Donner engineering representative or write us today.

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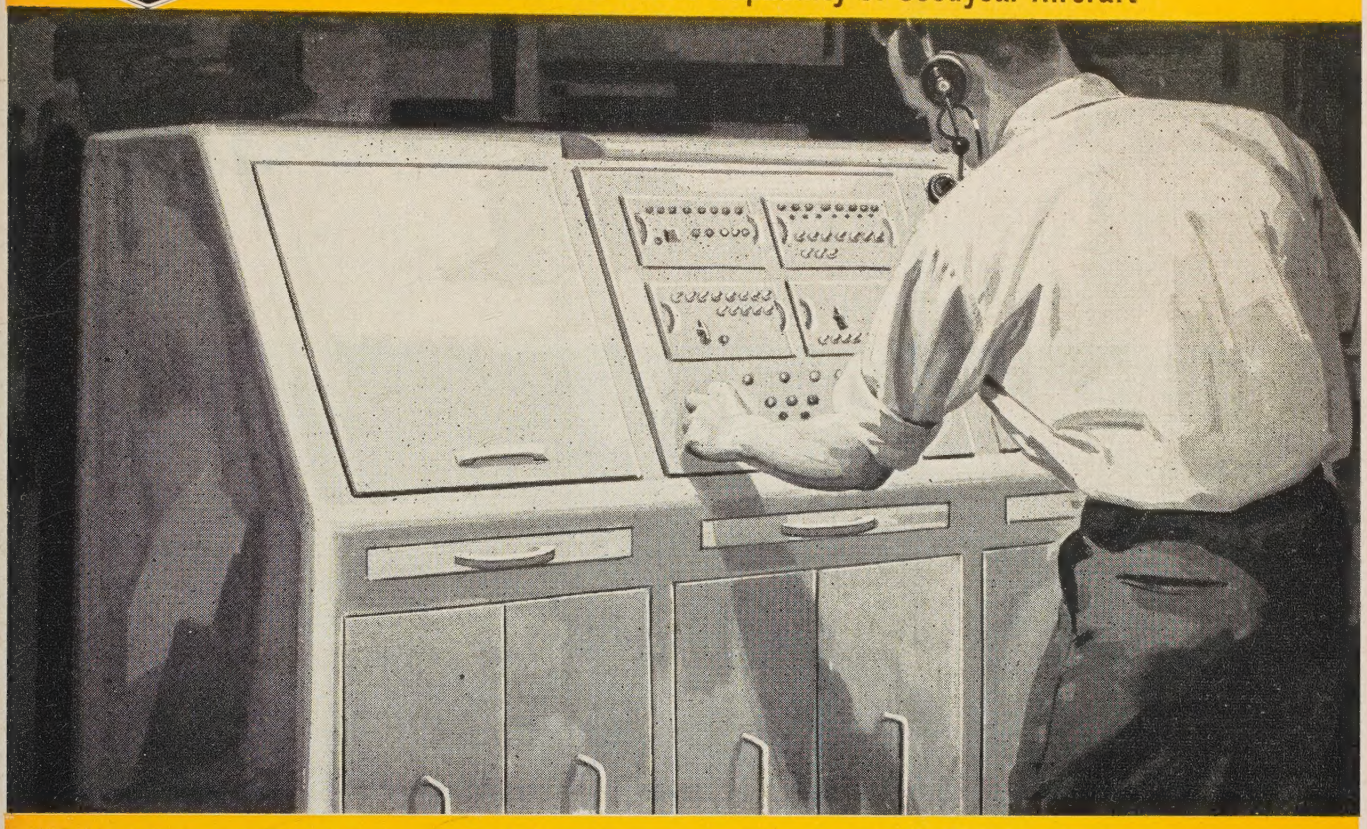
No. 1 on Reader Service Card

GOODYEAR

ELECTRONICS: Another Prime Capability of Goodyear Aircraft



GAC Electronic Test and Evaluation Equipment, like the Central Programmer and Evaluator, keeps equipment on the move from production line to firing line.

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Do you have a problem finding electronic test and checkout equipment that will meet your program requirements? The Central Programmer and Evaluator (CPE) made by Goodyear Aircraft Corporation (GAC) may well be the fastest, most economical solution you can find.

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ITEM: It has an inherent capability of 4,000 tests—from 3,000 to 3,800 more than other available equipment. And it has automatic self-fault-isolation and self-verification capabilities, can automatically fault-isolate equipment under test to several levels.

ITEM: Its accuracy ranges from ±.05% of true value at any point in the 1-600 volt scale to ±1.0% of true value at any point in the 50-100 mv scale—twice as great as other equipment currently sold.

If your target is versatile and reliable checkout equipment, write for full details on the Central Programmer and Evaluator to Goodyear Aircraft Corporation, Avionics Department, Dept. 914BG, Akron 15, Ohio.

Scientists—Engineers: Join a progressive, rapidly growing technical staff.
Contact C. G. Jones, Director, Technical Personnel

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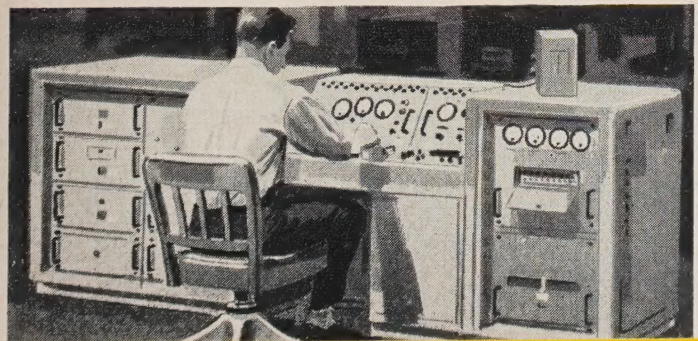
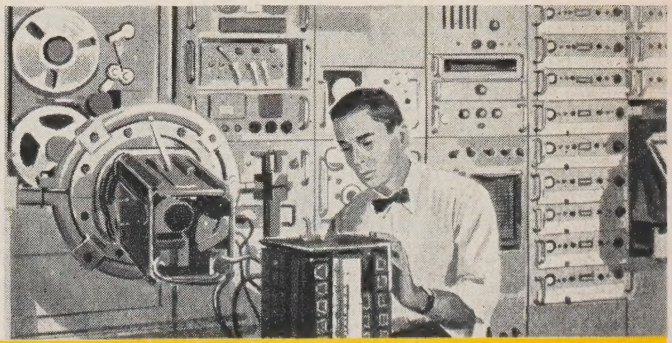


GAC missile guidance tester automatically and quantitatively checks complete Air Force Mace guidance system.



GAC telemetry system tester checks out airborne telemetry package for Navy's SUBROC missile.

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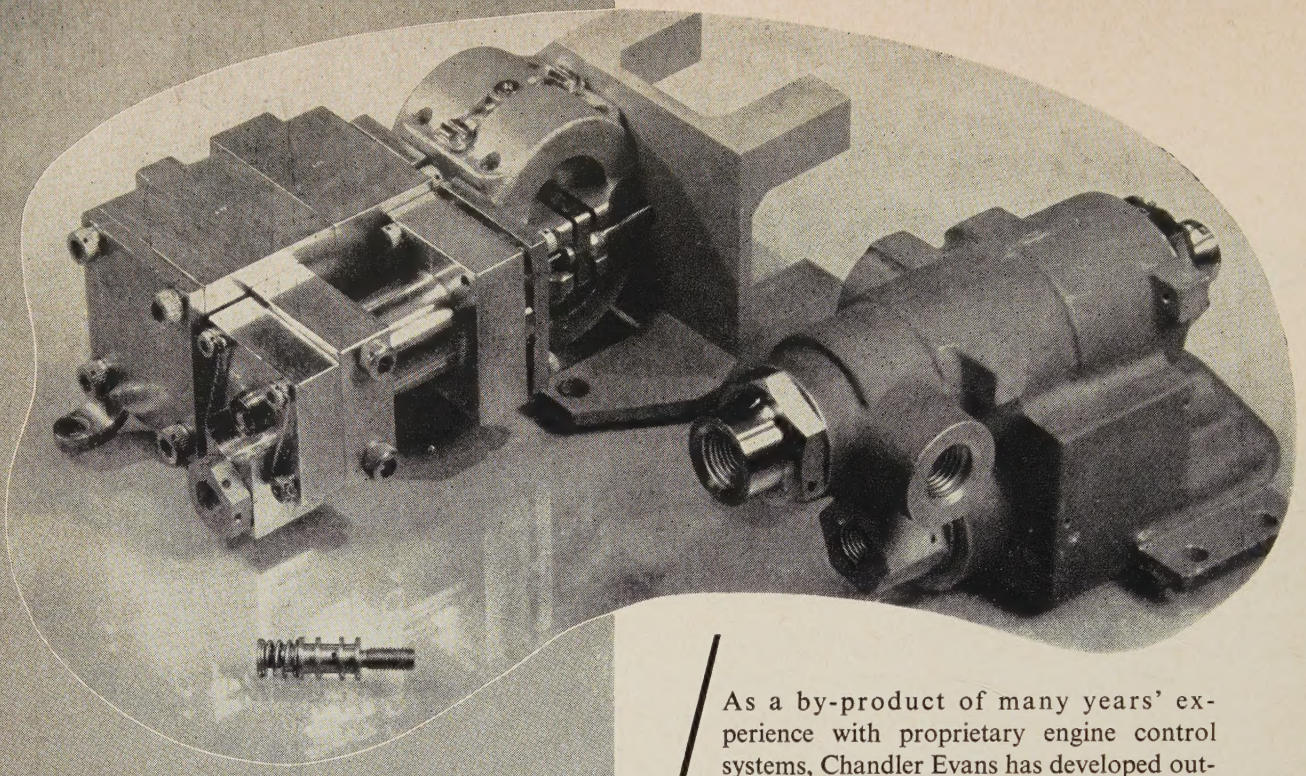
COMING

"Pep" and "pert," as you probably already know, are not only nice, short words but also acronyms for two "management techniques" that have been put forward as solutions to some of the ills besetting aerospace programing. How these techniques have worked out in practice will be described in a survey covering major aerospace contractors. ■ Cursory examination of most of the literature would often lead you to believe that there's nothing between the booster and the payload. To do our bit in remedying this odd gap, we will feature a comprehensive article on the upper-stage design of one of our most versatile satellite launch vehicles. ■ As has been pointed out, successful VTOL design hinges largely on powerplant development. An article next month will review in detail a jet configuration devised specially for the requirements of VTOL flight. Plasmas, which have become steadily more important for electronic design, will be covered in a basic analysis of their electromagnetic circuit characteristics.



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*Left—hydrogen peroxide valve; right—jet engine flow divider; foreground—accelerating valve

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technical articles in this issue abstracts

Management

Space programs and basic research boosted by AF reorganization

Effective this month, AF Systems Command succeeds ARDC, taking charge of all AF systems acquisition; AF Logistics Command takes over procurement of spares and operation of world-wide logistics system from AMC. This article reports on the AF reorganization, said to be designed for more effective management of ballistic missile and space programs.

by Randolph Hawthorne, Editor

space/aeronautics 36/1 (July '61) p. 52

Systems Engineering, Materials, Structures

Spacecraft temperature control: state of the art

Cites importance of spacecraft temperature stabilization and need for practical solutions of the heat-balance equations. Presents a heat-balance equation for a particular instant and area segment of an orbiting spacecraft; shown how to extend it over the entire spacecraft surface. Also discusses ratio of short-wave absorption to infrared emittance of surface material, a key factor in temperature control.

by Dieter Goetze, General Mills

space/aeronautics 36/1 (July '61) p. 55

Materials, Systems Engineering

Spacecraft temperature control: breakthrough on Transit

Discusses liquid organic surface coatings for spacecraft temperature control. Reports on work at ASD's Materials Center which indicates that these easily-applied coatings do not, as was feared, deteriorate and evaporate under ultraviolet light in space.

by Eileen B. Kress, AFSC

space/aeronautics 36/1 (July '61) p. 60

Propulsion, Systems Engineering

Which engine for the supersonic transport?

Reviews powerplants—straight turbojets, turbofans, and various combinations of gas turbines and ramjets—under consideration for the supersonic transport and evaluates them in terms of acceleration thrust capabilities, design pressure ratio, and inlet temperature.

by Andrew Sanne, Associate Editor

space/aeronautics 36/1 (July '61) p. 62

Dynamics, Systems Engineering

Dynamic pressure on a moving body

Discusses problems of dynamic pressure acting upon a body in flight, and uses nomographs to present the mathematical expressions necessary for the solution of these problems.

by Robert M. Sando, Westinghouse Electric

space/aeronautics 36/1 (July '61) p. 64

Propulsion, Ground Support Engineering, Structures

How to find the exhaust heat radiation of aluminized solid rockets

Analyzes the effect of aluminum on the radiative heat of solid-propellant rocket exhausts. Develops a general theory to explain the chemical changes undergone by the aluminum particles during combustion and show how these changes depend upon rocket geometry and in turn affect radiative exhaust heat.

by D. D. Kurtovich and G. T. Pinson, Boeing Airplane

space/aeronautics 36/1 (July '61) p. 66

Structures, Accessory Systems, Systems Engineering

Avro 748 has novel fail-safe features

Details of special design features of the Avro 748 aimed at long, trouble-free operating life for the operator who has limited facilities. Fail-safe structure and systems and arrangements for easy inspection, maintenance, and repair are outlined.

by Christopher Dawson, Associate Editor

space/aeronautics 36/1 (July '61) p. 71

Test Engineering

Orbital simulator tests satellite reliability

Reports on Lockheed's Hivos environmental simulator for reliability testing of spacecraft and their systems. Hivos is said to reproduce, as nearly as possible, the two most important conditions of space—low pressure and extremes of heat and cold—and to maintain them for long periods.

by W. G. Camack and C. A. Ellis, Lockheed Aircraft

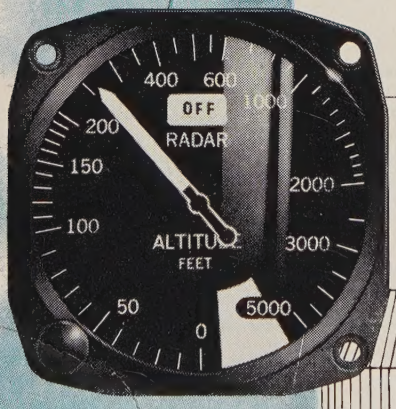
space/aeronautics 36/1 (July '61) p. 81

Micrometer Precision for

ALTITUDE MEASUREMENT

the Bendix-Pacific

RADAR ALTIMETER



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- Rugged . . . small (only 73.5 cu. in.)
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abstracts

continued from page 7

Electronics, Accessory Systems, Test Engineering, Data Processing

Growing trend to airborne digital computers

Tabular and analytic report on an industry-wide survey of developments in airborne digital computer design. Some 30 computers are tabulated, and a summary of vehicle-computer combinations is given.

by James Holahan, Electronics Editor

space/aeronautics 36/1 (July '61) p. 108

Electronics

Martin-Orlando solves guidance problem and unplugs information bottleneck

Reports on a simple, light-sensitive pickoff for measurement of gyroscopic angular deviations to prevent restraining torques. Also describes the intra-company communications system used by Martin-Orlando, where the pickoff was invented, to tell its engineers about technical developments of general interest.

by James Holahan, Electronics Editor

space/aeronautics 36/1 (July '61) p. 136

Electronics

Tunnel-diode logic looks good for spaceborne computers

Discusses suitability of tunnel diodes for use in spacecraft computers. Reports that they meet the basic requirements of inherent reliability (a special computer circuit can provide the feature of majority logic, or "voting," that increases reliability), small size, low weight, and low voltage and current requirements.

by James Hammill, General Electric

space/aeronautics 36/1 (July '61) p. 114

Production Engineering, Propulsion

Fissio-chemical reactor produces hydrazine from ammonia

Describes experiments with in-pile apparatus that have proved the feasibility of producing hydrazine from liquid ammonia. It is estimated that a fissio-chemical reactor setup can do the job at an amortized cost of about 15-40 cents per pound.

space/aeronautics 36/1 (Ju'y '61) p. 149

Electronics, Accessory Systems, Test Engineering

Ultra-precise magnetometer for undersea or space (Design Digest)

Design analysis of an advanced resonance-type magnetometer that makes possible measurements of magnetic field with a precision of one part in 5,000,000. Detailed drawings and diagrams are used to explain the devices operating principle.

by Bernard Kovit, Associate Editor

space/aeronautics 36/1 (Ju'y '61) p. 119

Accessory Components

Heaters for cryogenic bearings in Titan lox pump

Reports on a special heater developed to supply heat to a bearing in the lox pump gear drive of the Titan and keep the lox from freezing the bearing lubricants.

space/aeronautics 36/1 (July '61) p. 155

Electronics, Accessory Components, Test Engineering

Thermal switches and transducers for discrete and continuous temperature controls

Reports on thermal switches and transducers—rod-and-tube and bimetallic, liquid, gas, and vapor switches as well as resistance elements, thermistors, and thermocouples. Factors involved in selection and application are reviewed, and a table summarizes significant characteristics.

by William C. Moodie, Control Products

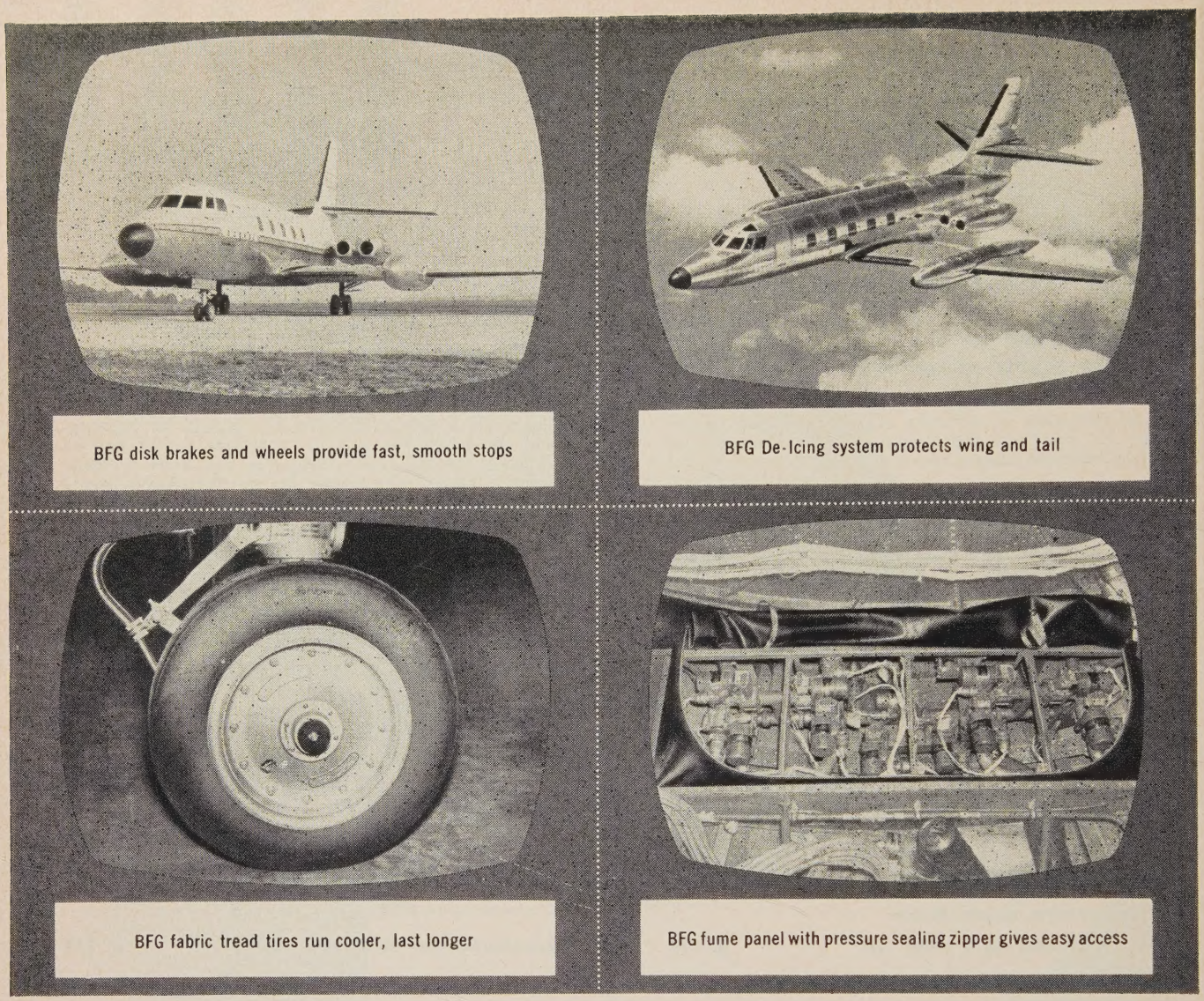
space/aeronautics 36/1 (July '61) p. 127

Electronics

Beacon system for capsule recovery uses CRT display

Summarizes the operation of the Sarah (*s*earch *a*nd *r*ecovery *a*nd *h*oming) beacon system used in the location and retrieval of space capsules and missile nose cones.

space/aeronautics 36/1 (July '61) p 187



BFG disk brakes and wheels provide fast, smooth stops

BFG De-Icing system protects wing and tail

BFG fabric tread tires run cooler, last longer

BFG fume panel with pressure sealing zipper gives easy access

B.F.Goodrich helps make the JetStar a small-field, all-weather performer

All-weather capability of the new Lockheed JetStar gets an assist from proven BFG pneumatic De-Icers, which equip the leading edges of wing and tail surfaces. The BFG system was chosen for its light weight and simplicity. An electronic timer activates the solenoid in the distributor valve which then pulsates the De-Icer with turbine bleed air.

Ability of the JetStar to operate from small fields, of less than 5000 feet, demands dependability on the runway. Here BFG disk brakes and wheels, of the same type used on big passenger airliners, provide fast, chatter-free stops. A thermally balanced brake design assures constant high torque throughout the life of the lining. And many of the JetStars will roll on BFG fabric-tread jet tires.

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product index to advertising

THIS IS A SPECIAL REFERENCE to the product information given in the advertisements in this issue. It is intended solely to help the reader make the best use of these ads. Therefore the index does not necessarily cover all the products made by each advertiser. Also, definitions and cross-listings are not intended to exhaustively describe each product but merely to make sure that each product can be found with reasonable ease by the reader looking for it.

Similar indexes to services and employment opportunities featured in ads follow this index.

Advertisements for which complete proofs were not available to the Editorial Department by the closing date are not necessarily covered by these indexes. (Proofs can be forwarded internally by the Production Department only for advertisements meeting the closing dates.)

For more detailed information on any product or service advertised in this issue or featured in its Product and Data Reviews, use the handy Reader Service Card.

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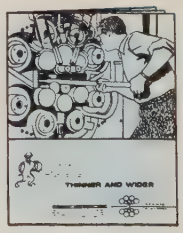

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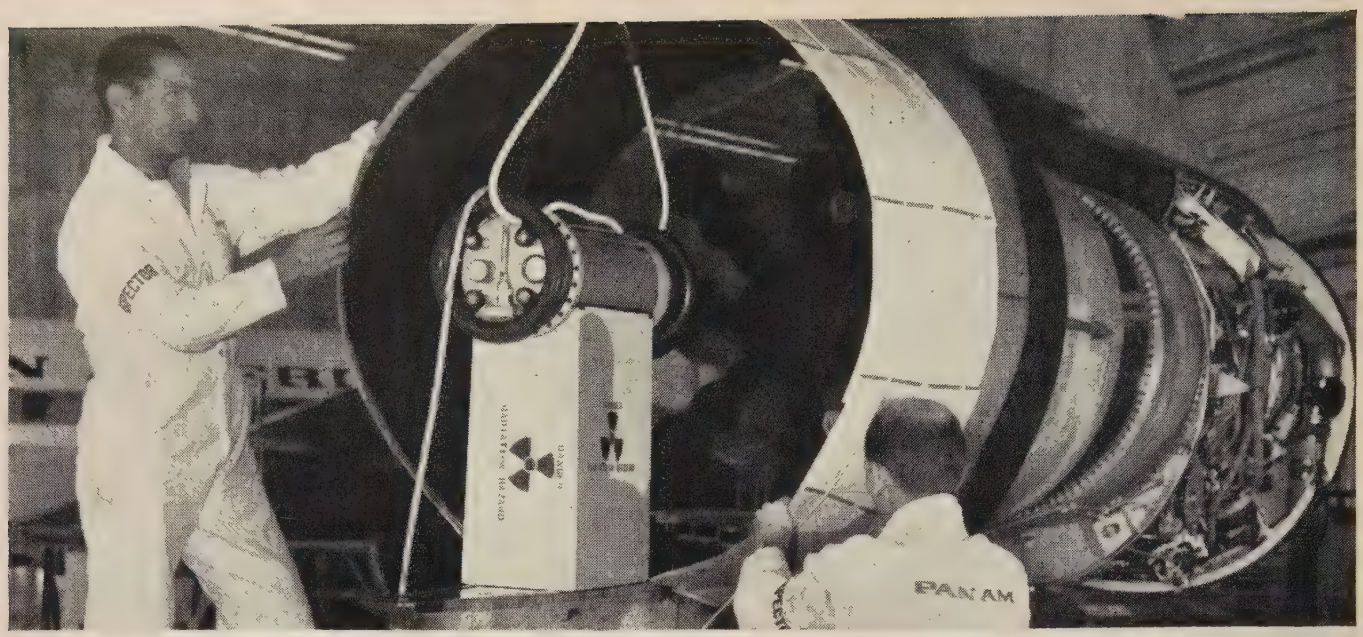

Pan Am inspectors position Kodak Industrial X-ray Film and 360° x-ray unit to radiograph jet engine thrust ejector.

It throttles the roar of a 16,000-lb. thrust

Thrust ejectors on jet engines must be examined every 400 hours. Pan American Airways does it radiographically—cuts inspection time more than 90%.

To remove the floating skin on a jet thrust ejector and check its insides takes a lot of expensive man-hours. But Pan Am gets the answer—now—in one-tenth the time.

By wrapping both Type AA and Type M Kodak Industrial X-ray Film around the ejector, a single exposure with a 360° x-ray head provides inspection of both thin and thicker sections of the unit.

This is another example of the way radiography saves time and guards quality. It inspects enclosed assemblies. It examines castings for inclusions, voids and shrink. It proves the soundness and continuity of welds. And in every case provides a record for reference.

Radiography can save you time, save money, and build a reputation for high-quality work. If you'd like to discuss how it can help you, get in touch with an x-ray dealer or write us for a Kodak Technical Representative to call.

Radiograph reveals structural parts sound but discovers an air pipe clamp is broken.

Now . . . Ready Pack in ROLLS and SHEETS Kodak Industrial X-ray Film, Types AA and M in 200-ft. rolls (16mm, 35mm, 70mm) and sheets (8 x 10, 10 x 12, 11 x 14, 14 x 17).

- No darkroom loading—film sealed in a light-tight envelope.
- Just place Ready Pack in position and expose.
- Film protected from dust, dirt, light and moisture.
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Kodak TRADE MARK

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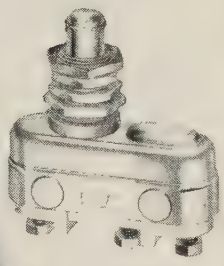
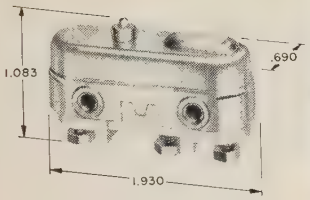
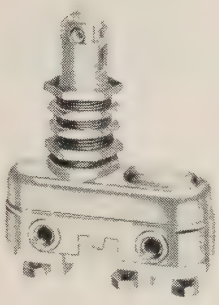
SWITCH RELIABILITY AT 1000°F



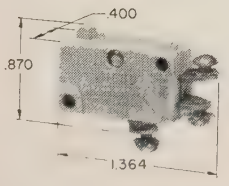


PIN PLUNGER

Switch featured at right has Overtravel Plunger



ROLLER PLUNGER



"V3" Small basic switch with synthetic mica case withstands operating temperatures to 600°F

These high temperature switches were originally designed for use on or near the afterburners of jet aircraft. Their precision performance in a temperature range of −65°F to +1000°F makes them ideally suited for high temperature applications. To insure reliability and precision, only laboratory-tested heat resistant materials are used in their manufacture. Switching elements are mounted on ceramic terminal blocks and protected with corrosion resistant monel enclosures. Actuators, terminal screws and nuts are stainless steel. At 1000°F, these switches exceed 10,000 operations while carrying a resistive load of 10 amps at 28 vdc. See the Yellow Pages for the nearby MICRO SWITCH Branch Office, or write for Catalogs 63 and 78.

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MICRO SWITCH Precision Switches

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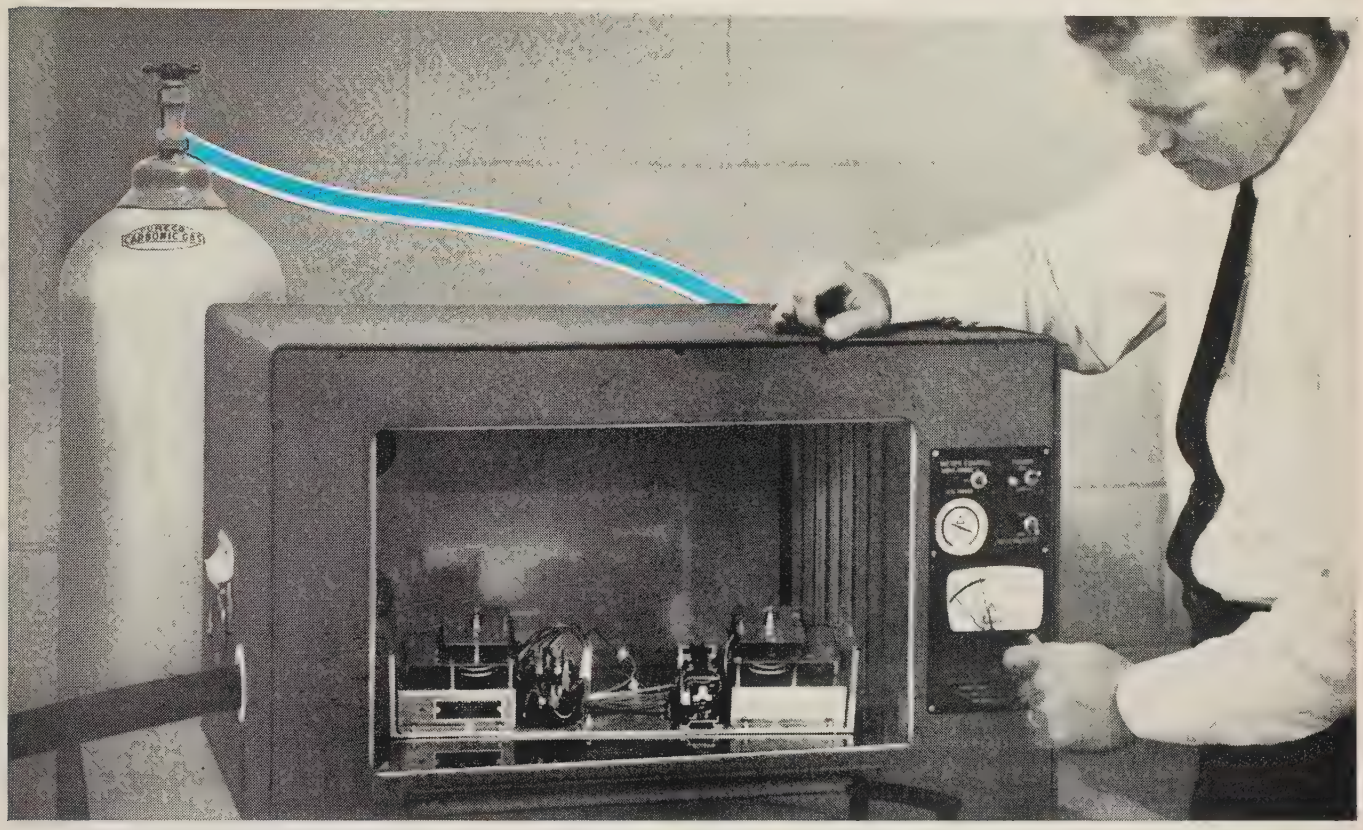
for reliable, flexible, low-cost environmental testing



SAVE WITH PURECO CO_2 "BLAST COLD"

Extremely close tolerances possible

Test chamber temperatures with extremely close tolerances can now be easily achieved with the Pureco CO_2 "*Blast Cold*" process. Tolerances of $\pm\frac{1}{2}°$ are possible! This close control is obtainable by using specially designed cabinets and controls (as illustrated) and Pureco CO_2. Such pinpoint accuracy makes Pureco CO_2 liquid ideal for shock testing and hot and cold cycle testing.

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This same simple Pureco CO_2 liquid direct injection process also provides refrigeration of unlimited capacity instantly . . . any time . . . anywhere. The Pureco CO_2 "*Blast Cold*" process can reduce temperatures from plus 500°F to —100°F in minutes. A minimum of mechanical devices in the system results in a high degree of reliability . . . there is virtually no danger of costly failures in the middle of a test.

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Since many environmental testing jobs are scattered around in plants, Pureco now supplies, in addition to cylinders, portable CO_2 bulk liquid units of 1000 lbs. capacity, as well as fixed units up to 60 tons or more capacity. Capital investment and maintenance costs are low . . . CO_2 receivers are normally supplied and maintained by Pure Carbonic on the customer's premises.

Have a trial "Blast Cold" demonstration

Pureco would like to demonstrate "*Blast Cold*" to you at *your* plant under *your* working conditions with no cost to you. Call your local Pureco representative or write:

PURECO CO_2

PURE CARBONIC

Pure Carbonic Company, A Division of Air Reduction Company, Incorporated
Nation-Wide Pureco CO_2 Service-Distributing Stations In Principal Cities
General Offices: 150 East 42nd Street, New York 17, N.Y.

No. 9 on Reader Service Card

Arma navigates new routes

Navigating with cross-staff and primitive compass, Prince Henry's Portuguese pilots took more than 80 years to find a route around Africa and reach India. The Spaniards took another 20 years to cross the Atlantic and reach the shores of Florida.

Today, missile-borne inertial guidance can navigate such distances in a matter of minutes and pin-point targets nearly half-way around the world. Other advantages of inertial navigation are immunity to outside interference, all-weather capability, salvo firing, and a minimum of ground equipment.

Arma, designer of America's first inertial guidance of intercontinental range accuracy, has these systems in full production with on-schedule deliveries. Although specified for the Atlas missile, the Arma system is equally adaptable to other aerospace programs and space exploration projects.

At Arma, research programs currently are exploring smaller, supersensitive devices for future generations of missile and space guidance systems. Arma, a division of American Bosch Arma Corporation, Garden City, New York. . . . The future is our business.

8321

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"Scotch" Brand HEAT reflective tape

No matter how heat-sensitive the surface, this new tape from 3M successfully protects against radiant temperatures up to 5,000°F. Reason enough for its being specified by Martin-Denver for protecting their ICBM Titan's delicate components, cables, plumbing, and other hardware from blast-off heat.

The unique characteristics of "Scotch" Brand Heat Reflective Tape are made possible by a construction of highly reflective aluminum foil laminated to glass cloth and coated with a specially formulated pressure-sensitive silicone adhesive. It stands up for short time periods of 5,000°F. and protects under continuous duty at 500°F.

Other new tapes from 3M for aerospace applications include tapes with remarkable vibration damping ability, and tapes to resist almost any corrosive attack. For information, contact your nearest "Scotch" Brand Tape Distributor or write 3M Co., 900 Bush Ave., St. Paul 6, Minnesota. Dept. IBL-71.

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3M COMPANY

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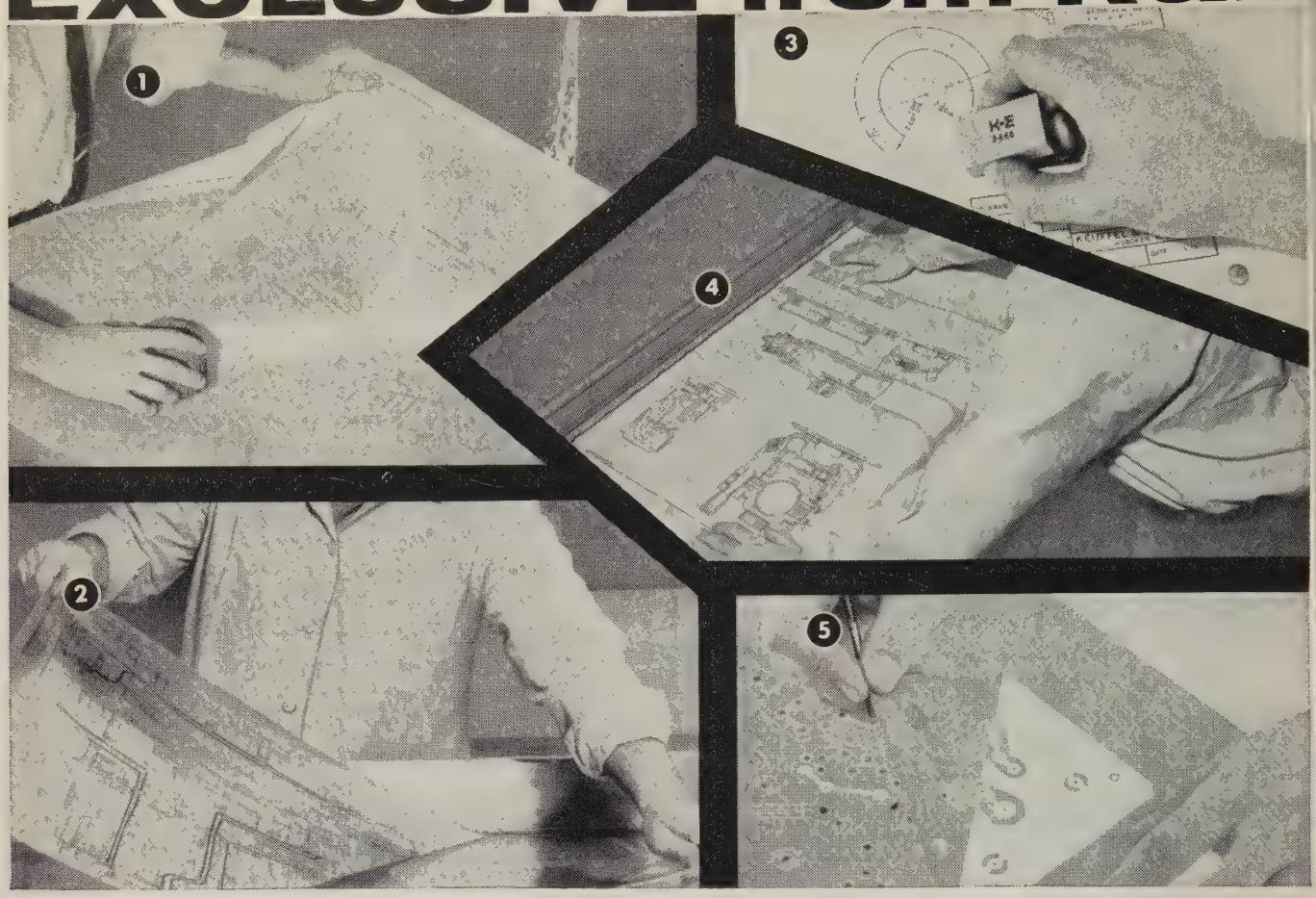

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and every film with "engineered" drafting surface

Only K&E offers you all the film-based media for your drafting and reproduction needs, and they're all *working* products, designed to permit additions or deletions. The same engineered drafting surface throughout enables you to standardize on drafting techniques, and the same base throughout means constant behavior characteristics under exposure to light, heat, moisture, etc.

1. HERCULENE® – the unchallenged leader among drafting films, with better than ever working properties for pencil, ink, and typing. Now with a choice of specialized writing mates: *Duralar* plastic pencils render tracings that are completely washable in soap and water . . . new *Ruwe* pencils have all the fine "feel" of graphite, yet resist smudging better than graphite on regular paper.

2. PHOTACT® – the photographic second original *on film* that can be processed with regular *paper* developer. Image lines can be *manually* erased, too (no eradicators needed). Underneath – an excellent drafting surface for changes or additions in pencil, ink or typing. Available in three film types: Contact, Direct Positive, and Projection.

3. DUPRO® – for ink-like second originals that can serve as working copies. Image lines are smudge-proof, with appearance and permanence of photography, yet are easily removed with soft vinyl eraser. For additions or changes in pencil, ink or typing: a perfectly balanced drafting surface underneath. Another advantage: wash-off emulsion permits processing in room light – *no darkroom needed.*

4. HELIOS® – for intermediates of exceptional ruggedness, produced easily, quickly, and at *low cost* by the standard dry diazo process. Mechanical erasure removes image lines (no eradicators needed); engineered drafting surface on the reverse side. Unsurpassed line density and background clarity – black line or sepia.

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Another Way Grove Sets Regulator Standards for Others to Follow

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techniques
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heat shield
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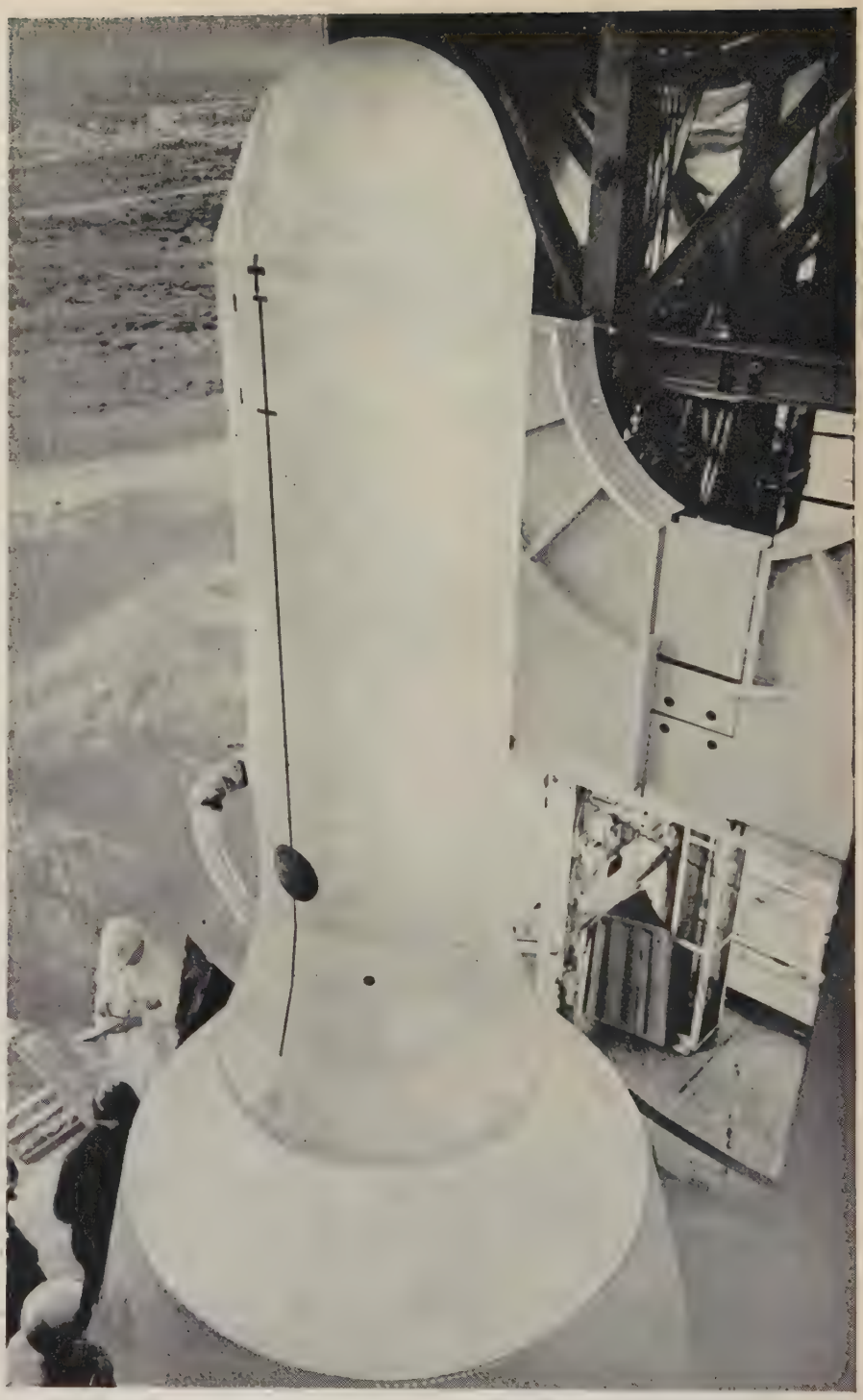

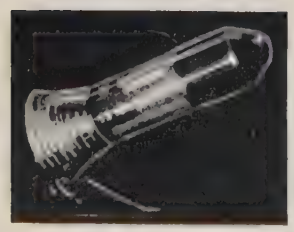

ABLATIVE MATERIALS ENABLE FIRST ICBM NOSE CONE RECOVERY
This RVX1-5 was the first nose cone to travel full ICBM range and be successfully recovered intact. Speeds up to 15,000 mph, temperatures to 12,000°F, high heat inputs, and high acceleration and deceleration forces were encountered. The RVX1-5 was enabled to withstand these severe re-entry conditions through the use of REFRASIL[1] and AVCOITE[2] ablative heat shield materials.

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[1] *REFRASIL is a registered trade mark of H. I. THOMPSON FIBER GLASS CO.* [2] *AVCOITE is a registered trade mark of the AVCO CORPORATION.*

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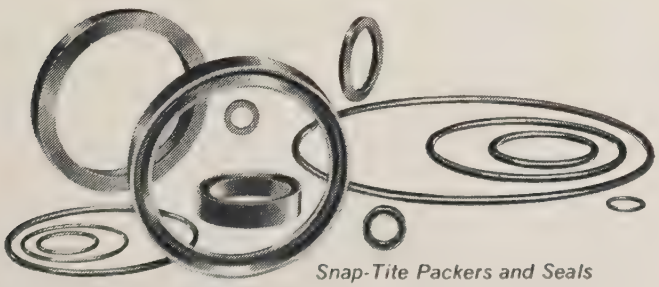
A complete choice of packers and seals permits Snap-Tite quick-disconnect couplings to handle over 600 different fluids! *(some of them mighty tough)*

Whatever fluid you're working with, chances are Snap-Tite couplings can handle it. Because every-one of the thousands of Snap-Tite quick-connect valved couplings comes with a wide choice of rubber packers and seals, selected according to the fluid in use. The right choice, of course, is vital for the seal is the very heart of the coupling.

To assist you in the proper selection of coupling seal material, Snap-Tite, with the assistance of suppliers of synthetic rubber materials, has recently compiled a comprehensive Packer Usage Guide —the first of its kind in the industry.

For the Packer Usage Guide, and for complete information on the correct choice of quick-connect, quick-disconnect couplings for the fluids *you* use, write Snap-Tite, Inc., Union City, Pa.



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Use it as
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or develop it
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Lino-Writ 5, proved the most dependable direct writing photo-recording paper you can use, now adds a new bonus: you can use it as a completely dry process paper, or you can process it, for permanent trace results, with Du Pont's new Direct Writing Paper Processing Chemicals Kit.

Improved Lino-Writ 5 is still outstanding for dry-processed image stability and requires no stabilizing treatment for handling under normal room light conditions. Records may now be processed for greater permanence, for making reproductions with diazo equipment or for handling for prolonged periods under intense lighting.

Improved Lino-Writ 5: up to 100,000 ips... easy-to-read traces ... and now, use it either dry or wet process.

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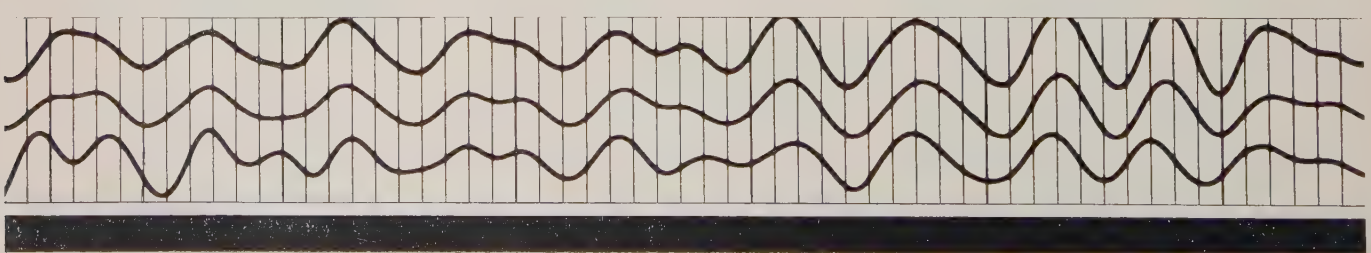

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No. 142 on Reader Service Card ➡

BENDIX BRAKES GIVE TWA 200,000 RAKE STOPS WITH NOT ONE FAILURE

S. L. Higginbottom
Assistant Vice President
Engineering, Flight Test & Inspection
Trans World Airlines, Inc.

TWA

TRANS WORLD AIRLINES, Inc.

MID-CONTINENT INTERNATIONAL AIRPORT,
KANSAS CITY 8, MISSOURI, U. S. A.

March 31, 1961

Mr. R. W. Whitesell
Director of Marketing
The Bendix Corporation
Bendix Products Division
South Bend 20, Indiana

Subject: Bendix Wheel and Brake Equipment

Dear Mr. Whitesell:

A review of the performance of the Bendix wheel and brake equipment on TWA's fleet of Boeing 707-131 aircraft indicates why we in TWA have a high regard for the Bendix equipment.

With more than twenty-three months of service representing approximately 25,000 landings (200,000 brake stops), we have yet to experience a brake failure. Similarly, wheel service has been excellent. The TWA flight crews likewise share our confidence.

We feel one reason for the excellent record is the effective and responsive service support. In addition to full time representation here at TWA's Mid-Continent Overhaul Base, field representation was provided throughout the training and indoctrination period at all of our Jet stations and have been promptly available on call whenever questions or problems occurred.

Very truly yours,

S. L. Higginbottom
Assistant Vice President
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r. Higginbottom's comments coincide with those of ost commercial, military, and business aircraft people. Bendix brakes have wide appeal to all segments of e air transportation market. Pilots have full confidence the brakes' dependable performance. Maintenance en like the reduced turnaround time. Controllers appreciate the lower cost-per-landing that results from use of the brakes.

The safety, dependability, and economy of these aircraft brakes stem from the superior designs, quality materials, and specialized background of Bendix—world's most experienced brake manufacturer.

Bendix PRODUCTS DIVISION South Bend, IND.

THE Bendix CORPORATION

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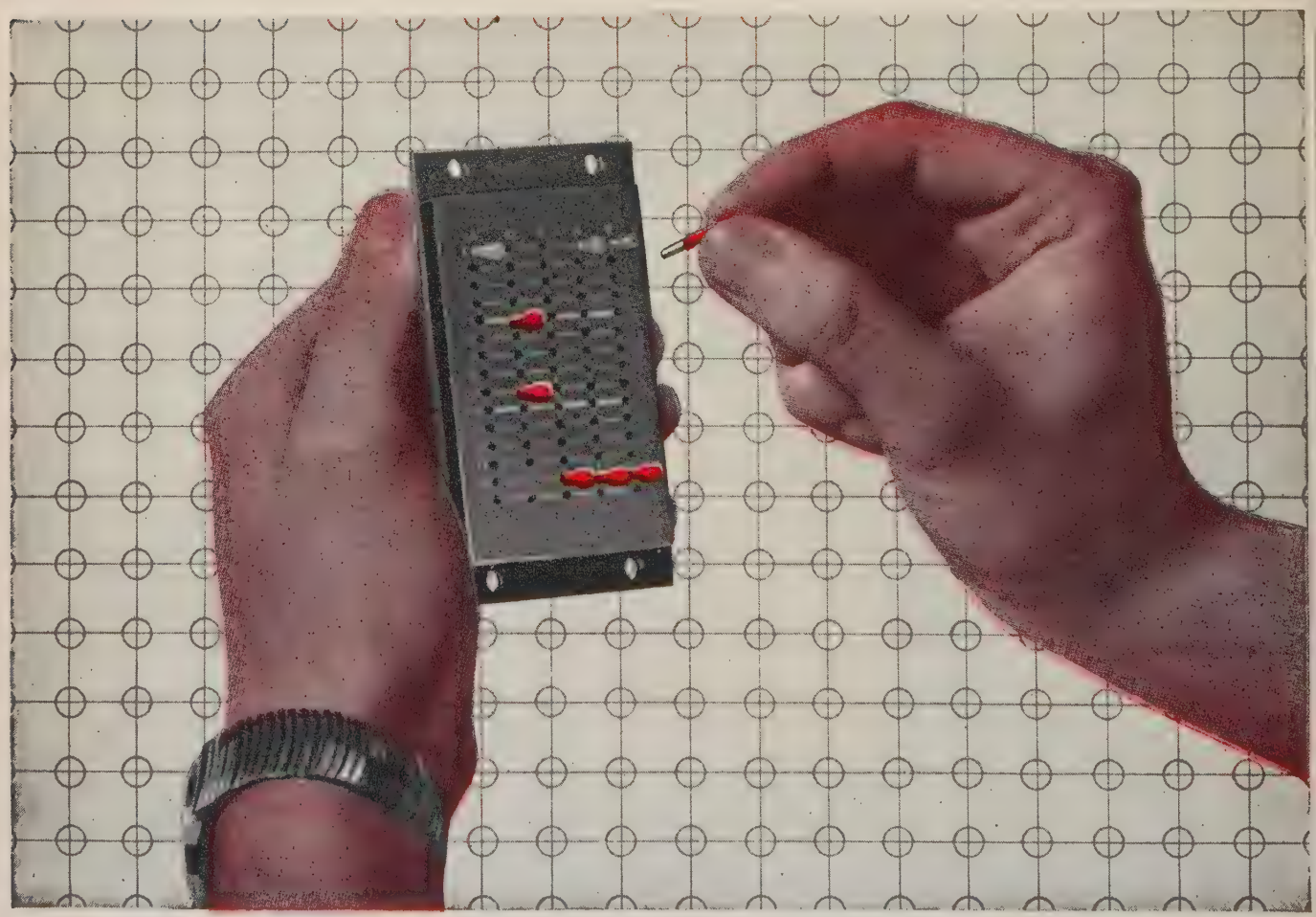
AMP PINBOARDS can do a host of dry circuit switching or commoning functions . . . permit numerous matrixes in one assembly. Complicated switching functions can be accomplished by simply inserting or removing a pin.

You can use these PINBOARDS as modular building blocks for instrumentation applications, automated tooling, test equipment, data processing . . . any variety of size and grid arrangements in multiples of a basic 15 x 5 hole pattern. Contact springs can be bussed in any combination desired. And for safety, there are no exposed conducting surfaces on the rear side of the board. The conducting area of the pin is safely inside board before contact is made with mating springs.

AMP PINBOARDS are factory pre-wired to your specifications . . . with standard or special silk screen legends. Designed for simplicity . . . flexibility . . . reliability . . . with three amperes continuous current rating.

Write for complete specifications.



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No. 17 on Reader Service Card

editorial

What's sauce for Ghana . . .

ONE OF the most successful lobbies today is formed by the people who believe that this country should have a strong foreign-aid program. These people are about to score a major victory. After earlier threats to do so, the government has finally gone to Congress with a request for long-range appropriations—covering up to five years—for certain loans to foreign countries.

The Administration and the advocates of foreign aid argue that, in some cases, the task of helping other countries has become so vast and so complex that it no longer can be handled within our traditional annual cycle of budgeting—that these programs can succeed only if it is reasonably certain that there will be enough money not just this year but in later years, too. Sooner or later, Congress will have to buy this argument.

Now what we would like to know is this: If foreign aid can be put on a long-range budget, why not defense—especially when it comes to aerospace programs? It's a fact that, in vastness and complexity, few tasks rival those of the aerospace field. It's also a fact that the good old practice of throwing everything in the defense budget up for grabs every year has again and again produced chaos and wasted a lot of money, time, and brains. Think of all the projects that have been axed or throttled back because short-term priorities left no money for them, all the projects doomed from their beginning by niggardly financing, all the projects that should not really have been started but were, because, "after all, we'd need only a couple hundred thousand this year."

The Pentagon chiefs themselves appear to have realized that it is nonsense to budget for a year when you are planning for a decade. Charles J. Hitch, the new DOD comptroller, has announced that major defense programs from now on will be proposed in the form of "packages"—actually detailed breakdowns describing the entire project, from study to operation, in terms of technical requirements and goals, cost, and timing.

The idea of "package" proposals is a step in the right direction. Planning alone, however, doesn't get things done. It's money that talks.

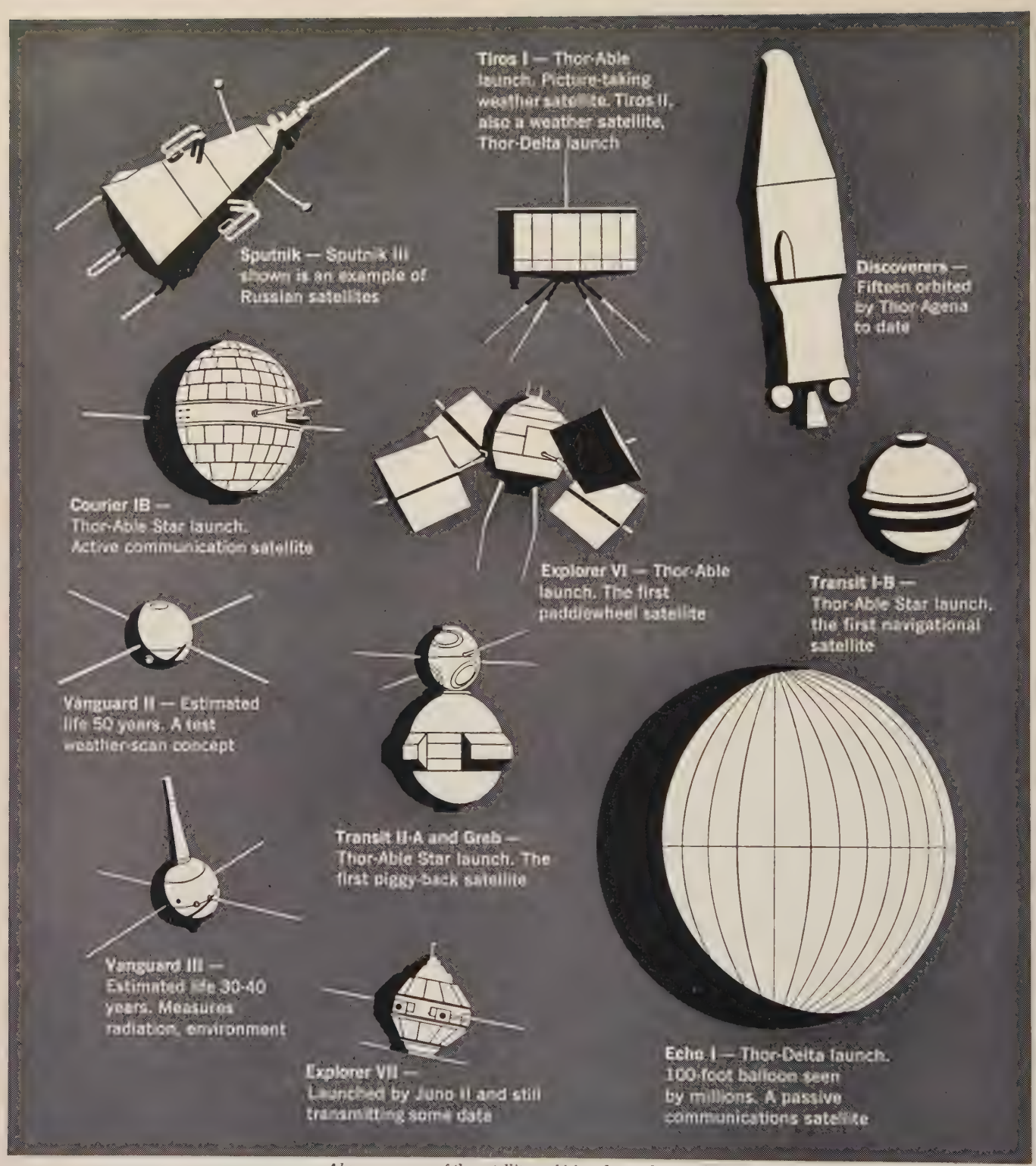
THE BASIC benefit of long-range budgeting for major aerospace programs would be stability:

- There would be fewer false and duplicate and triplicate starts. It's not so easy to promote a beguiling but not necessarily promising project when you are talking in hundreds of millions of dollars as when you are talking in hundreds of thousands.
- Mid-project cancellations for non-technical reasons would become much rarer. True, even on long-range programs financed on the basis now proposed for foreign aid, both the Administration and Congress would retain the power of cancellation. But psychologically the odds are heavily against the use of this power. Administrators and legislators no more like to go back on their word than do ordinary mortals.

Most of the aerospace industry, we feel certain, agrees with us on the need for long-range aerospace budgeting. In fact, the clinching argument made against this idea almost invariably has nothing to do with the merits of the case. Rather it simply asserts that "Congress won't stand for it."

But that simply is not so. Attached as it is to its powers, Congress has relinquished many of them under the pressure of economic and technological change. It will do so again if the pressure is strong enough.

Who will create the pressure in the case of long-range budgeting? We cannot believe that the advocates of foreign aid feel more strongly about dams for Ruritania than the aerospace industry feels about its own work. The foreign-aid lobby had to argue for years to come as close to victory as it is now. The aerospace industry, we hope, can put up an argument, too.


Tiros I — Thor-Able launch. Picture-taking weather satellite. Tiros II, also a weather satellite, Thor-Delta launch
Sputnik — Sputnik III shown as an example of Russian satellites
Discoverers — Fifteen orbited by Thor-Agena to date
Courier IB — Thor-Able Star launch. Active communication satellite
Explorer VI — Thor-Able launch. The first paddlewheel satellite
Transit I-B — Thor-Able Star launch, the first navigational satellite
Vanguard II — Estimated life 50 years. A test weather-scan concept
Transit II-A and Greb — Thor-Able Star launch. The first piggy-back satellite
Vanguard III — Estimated life 30-40 years. Measures radiation environment
Explorer VII — Launched by Juno II and still transmitting some data
Echo I — Thor-Delta launch. 100-foot balloon seen by millions. A passive communications satellite

Above are some of the satellites orbiting the earth, a majority of which were launched by Douglas Thor

The Douglas Thor rocket has orbited more satellites than all other rockets combined!

Of all satellites put in orbit since 1958, 55% were launched by the Air Force-NASA Thor IRBM. In its last 83 tactical and space firings by the Air Force, Navy and NASA, 86% have been completely successful – a reliability inherited from forty years of Douglas experience in aviation and 21 years in missiles and space.

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Washington Briefing

McNamara's lost cause

DEFENSE SECRETARY Robert McNamara notwithstanding, the odds are sharply against the start of work on a tri-service tactical fighter in fiscal 1962.

McNamara is convinced that one airplane—possibly with variable wings—can meet the needs of the Army, the Navy, and USAF. But one advisory group after another has told the Defense Secretary that it isn't so.

The budget for fiscal 1962 contains $45 million to begin the development of a tactical fighter that allegedly will meet the requirements of all three services. Congress will undoubtedly vote McNamara the entire sum, who will not give up on the tri-service approach until he has personally decided that it is simply not feasible.

So far, McNamara has received reports from the services, from a group of DOD civilians hand-picked by himself, from the same group of civilians with top brass thrown in for good measure, and from Dr. Harold Brown, the Director of Defense Research and Engineering. Each of the reports said the services' requirements are so different that no single aircraft to meet them all can be built. Sooner or later, McNamara will reach the same conclusion and authorize the development of at least two, and possibly even three, tactical fighters.

The **Air Force** has already compromised as much as it is going to in modifying its original TFX tactical fighter specs. Yet the **Navy** still thinks the AF plane is too heavy. It also wants folding wings for carrier operation, which complicates the matter further. The **Army** as always thinks the vehicles proposed by the two other services fly too high and too fast to provide the proper kind of support for ground troops.

The cost of an aircraft that flies fast enough to make the Air Force happy, slow enough to satisfy the Army, and weighs so little that it can be stored aboard carriers in appreciable numbers would

be formidable, even without the added requirement of operation from and onto short or non-existent runways. In any case, Army officials think the R&D experts are overoptimistic about the state of the art of V-STOL design.

Both the Navy and USAF are trying to line up Army support for their TFX preferences. USAF demonstrated the F-105 to Army brass at Nellis AFB, N. M., and the Navy did the same at Cherry Point, N. C., with the A4D. Either vehicle would be an interim plane, purchased to equip 11 Tactical Air Command squadrons.

USAF, while favoring the F-105, has told the Army, "You pick the interim plane and we'll fly it," in hopes that the Army will ultimately support its

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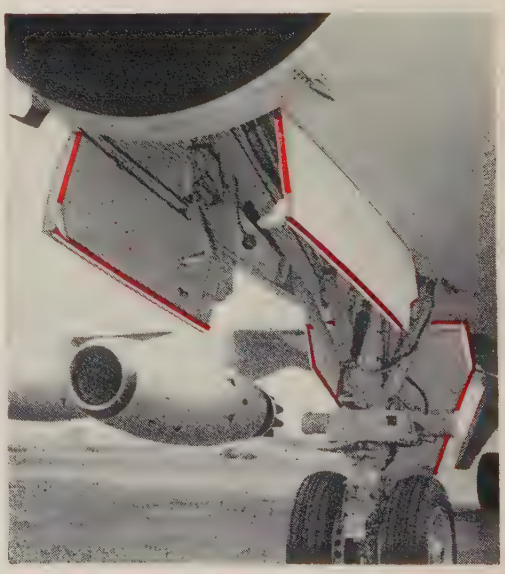
Courtesy Convair Division, General Dynamics Corp



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No. 18 on Reader Service Card

position on the TFX. So far, the Army has refused to choose either an interim tactical fighter or support anyone on the TFX, hoping to avoid ill feelings. But sooner or later it will have to support either the Navy or USAF.

As soon as McNamara becomes reconciled to the hopelessness of a tri-service fighter, the TFX competition will start anew. The Navy will seek to have its share of the funds assigned to continued development of the now-cancelled Missileer-Eagle combination and USAF will push for a Mach 2 fighter with V-STOL characteristics. However the two blue-suit services make out with McNamara, it is a safe bet that, with the current White House emphasis on limited-war capabilities, the Army's requirements will be included in any final design.

. . . . .

Aerospace firms are in for a substantial batch of new business as a result of President Kennedy's decision to meet the Russian challenge in space and especially to beef up the man-on-the-moon project.

Capitol Hill is expected to go along with the President's newest space proposals. Before he read his special message to Congress, important members of the Senate and House Space Committees were briefed by Vice President Johnson. Among them were Senator Styles Bridges (R., N.H.) and Robert S. Kerr (D., Okla.) and Representative Overton Brooks (D., La.). These men and their colleagues promised Johnson they would push for acceptance of the Kennedy space program.

According to Robert C. Seamans, Jr., NASA's associate administrator, the latest version of the space program will add $549 million to the agency's budget for fiscal 1962 as well as $77 million to DOD's budget. The man-in-space and lunar projects alone will total $531 million ($454 million for NASA, $77 million for DOD).

NASA also is to get $23 million for the Rover nuclear rocket (including $15 million for test facilities, $50 million for communication satellites, and $22 million for weather satellites. Another $53 million is earmarked for the Weather Bureau's work on the Nimbus weather satellites.

Dr. Hugh L. Dryden, NASA's deputy administrator, says that, while the agency's 1962 budget for work on solid rockets remains at the $3.1 million originally proposed by Eisenhower, the $77 million added to DOD's money will lead to a sharp upswing in industry work on solids. He reports that $15 million of DOD's extra cash will be used to buy a Centaur-sized Titan II booster as a back-up for NASA's Nova project. The other $62 million in Pentagon money is intended for the development of solid booster and upper stages for the Nova. The final choice between liquid and solid Nova engines for getting the Apollo three-man vehicle to the moon and back will be made by NASA, according to Dryden.

For the aerospace industry, Kennedy's request for more funds for fiscal 1962 as well as for $7-9 billion for the man-in-space program over the next five years means that **the U.S. will spend $25-$30 billion on all its space projects in the next five years.** The annual NASA budget level, Dryden reports, will be $4-$5 billion rather than the $2-$3 billion previously estimated. Before the 1960s end, NASA expects to spend $20-$40 billion on lunar projects alone.

The two changes made in NASA's budget by President Kennedy have raised the agency's budget request for 1962 by 61 per cent—from $1.1 billion in January to $1.78 billion now. Nearly $476 million of the added $675 million will go for R&D programs. (Facilities construction and salaries account for the rest.)

Oddly enough, Eisenhower's original $7.6 million request for research grants and contracts (which cover basic research activities) has remained unchanged. NASA thinks this sum is sufficient.

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No. 19 on Reader Service Card

USAF WILLING TO LET ARMY HAVE BIGGER PLANES, BUT WANTS TO KEEP MONOPOLY IN SPACE

The Air Force seems ready to agree to modification of the 5000-lb weight restriction on Army aircraft but appears much less anxious to share its newly assigned role as the nation's space force. Discussions about modifying the weight limit on Army aircraft have been underway between Army Chief of Staff George Decker and AF Chief Thomas D. White. The conversations will continue with Gen. Curtis E. LeMay, White's successor, and will even cover the arming of Army planes.

WEIGHT LIMIT CERTAIN TO BE RAISED

The Army has long felt that the 5000-lb limit hampers its organic aviation and has succeeded in getting several exceptions (such as the Grumman Mohawk and the de Havilland Caribou) approved. The Army-USAF discussions will undoubtedly result in an increase in the weight limit.

In testimony before the House Science and Astronautics Committee, AF officials indicated that they will not try to take over space projects assigned to the other services. They also said, however, that they foresee few "special circumstances" which will warrant taking future space programs out of the AF R&D setup. In a March 6 DOD directive, R&D priority on space was assigned to AF except under "unusual circumstances."

AF ON ZEUS: NOT INTERESTED

The Air Force will not seek control over the Zeus anti-missile because this design has no provision for inspection before a kill. But, AF says, future anti-missiles and anti-satellites with the ability to inspect multiple targets logically fall within its domain.

The Air Force also holds that follow-ons to the Army's Project Advent and the Navy's Sea Scout proposal to launch satellites from the ocean should be reviewed by DOD "to determine the appropriate service to continue the program."

Although the Bell D-250 and the Hiller 1100 were selected from 19 proposals as the winners of the Army's design competition for a light observation helicopter (LOH), Army officials are still willing to look at prototypes other manufacturers may produce. The LOH is designed to replace the L-19 and the H-13 and H-29 copters, which now account for 3200 vehicles in the Army inventory. A total of the LOH is expected to reach 4000 LOHs is expected to be bought. At a unit price of $22,500-$50,000, this may amount to $200 million in contracts.
Under present plans, Bell and Hiller will both use the 250-hp Allison T63 shaft turbine. Each will build about seven prototypes, and the winning design will be ordered into production in mid-'63. Deployment to troops is expected about '65.
The LOH will be a lightweight, single-rotor, four-place vehicle carrying a 400-lb payload plus pilot and fuel. It will cruise at 110 knots and weigh 2400 lb at takeoff. A C-130 will be able to carry four LOHs with only minor dismantling.

FULL DETAILS ON VEHICLE PROCUREMENT PLANS

All three military services have given the House and Senate Armed Services Committees full details on the aircraft and missiles they expect to purchase if Congress provides the new money requested in the Eisenhower and Kennedy budget messages. Army hopes to earmark $120.7 million for Raytheon Hawk purchases plus another $25 million to improve the missile's capabilities. Some $78.4 million is sought for Nike-Hercules GSE, but no new missiles of this type will be bought. The Redeye troop-carried anti-aircraft missile is down for $13 million, the Honest John for $16.7 million, the Sergeant for $93.6 million, and the French Entac anti-tank missile for $9.8 million. The sums sought for the Pershing were deleted by the censors.

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Overall, the Army wants $550.3 million for surface-to-air missiles and $211 million for surface-to-surface missiles.

The Navy's total allocation of nearly $1.6 billion for planes will buy 644 aircraft—24 A2F-1s, 180 A4D-5s, 88 F4H-1s, 72 F8U-2Ns, 14 Hr(X)s, 48 HU2K-1s, 42 HSS-2s, 70 HUS-1s, 36 P3V-1s, 48 S2F-3s, 10 T-39 jet trainers, and 12 W2F-1s.

Overall missile obligations include $246.4 million to buy the Sparrow III, $37.8 million the Sidewinder 1C ($25.3 million), Terrier (about $68 million), the Tartar ($45.3 million), the Talos ($36.8 million), the Bullpup ($26.3 million), and the first Subroc anti-sub missiles ($6.8 million). The sums for Polaris procurement were knocked out by the censors. Other Navy requests cover 165 Q2C drones ($16.5 million), 300 KD2Bs ($5.6 million), 400 KD2R-5s (at $1.9 million), 50 F9F-6K conversions ($2.8 million), and ASW drone copters costing $8.7 million. Astronautics is down for $4.8 million, and $1 million is assigned to missiles industrial facilities.

NAVY WANTS TO BUY 965 DRONES

The Marine Corps will procure 300 Hawks at $27 million and will invest over $12 million in Redeyes. About 250 surface-to-surface anti-tank missiles will also be procured with Marine R&D funds, but only after Army tests of the Entac.

USAF's $3.5 billion in new money for aircraft includes $369.9 million for the F-105D, $230 million for the KC-135, and $236.7 million for the C-130E. Of the $2.8 billion listed for missile purchases, Atlas will account for $201.6 million, Titan for $1.1 billion, Minuteman for $923 million, Hound Dog for $131.4 million, Bullpup for $16.3 million, Bullpup trainers for $10.4 million, and Q2C drones for $10.9. The rest of the money covers ballistic missile support, modifications, component improvement, industrial facilities, and a classified $122 million program.

NAVY AFRAID DOD IS CUTTING BACK ITS AIRCRAFT PROCUREMENT TOO SHARPLY

Navy officials are getting concerned about the number of new airplanes DOD is permitting it to buy. Original Navy budget request for '62 was for 1247 aircraft ($2.1 billion), but DOD only authorized 644 ($1.6 billion).

7200 ACTIVE PLANES PLANNED

To maintain the active plane inventory at the desired level of 7200, about $1 billion a year extra will be needed in the future. As things stand now, the 6900 planes in service will drop to 6600 in '62 and may fall to 3700 by '70 unless procurement is doubled for several years.

Among the Navy's long-range aircraft goals are 967 F8U-2N Crusaders, 574 F4H Phantoms, 360 HSS helicopters for ASW, 260 HU2-K Seasprites, 350 A2F-1 Intruders, and about 478 HUS-1 anti-sub helicopters. In addition, the Navy would like to procure 1000 A4D-5 Skyhawks through '63.

Between two and five per cent (measured by acquisition cost) of the USAF-owned machine tools are being replaced every year. The program, which involves replacement of four old machines with one high-performance new one, means AF will have fewer tools with improved capabilities by the end of the decade.

Finding that present equipment is designed primarily for high production rates, AF has concluded that what it now needs is more versatility for small-lot runs. The tendency now is to de-emphasize special-purpose machines and concentrate on types with multiple use.

The number and value of the tools in the AF inventory has been declining steadily. At the end of '58, AF owned 63,000 tools worth $957 million. At the end of '60, the total had dropped to 47,000 tools valued at $778 million. The goal for '70 is an inventory of 30,000 machine tools. AF expects to have bought 5000 modern machines by then, many of them numerically controlled.

The sums granted by Congress for USAF machine tool modernization have been encouraging—they rose from $3 million in fiscal '59 to $15 million in '60 and $25 million in '61.

Joseph S. Imirie, AF's Assistant Secretary for Materiel, says USAF has four major objectives in its machine tool replacement program: (1) reduce tooling costs; (2) reduce the human-error factor; (3) assure exact repeatability; (4) minimize machine variables.

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MECHANICS DIVISION (Los Angeles). Responsibilities of the Propulsion, Engineering Mechanics, and Aerosciences Laboratories within this division include: analyzing and evaluating performance of rocket engines, propellants and propulsion subsystems and components; conception, design, development, and evaluation of ballistic missile and space vehicle systems; development and implementation of structural, dynamic, aerodynamic, and re-entry vehicle research and development concepts for both ballistic missile and space vehicle programs; and development of new subsystems for missile and spacecraft applications.

SYSTEMS RESEARCH AND ANALYSIS DIVISION (Los Angeles). *Systems Research Laboratory* activities include: management of complete space and missile systems studies including initial design; operations analysis; preliminary design in such areas as structures and aeromechanical and electromechanical systems; trajectory and error analysis; space navigation; and communication systems. *Computation and Data Reduction Center* performs the following functions: numerical analysis; applied mathematics; statistical analysis; scientific programming; computational systems programming; data processing analysis; and test evaluation programming and analysis.

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RESEARCH LABORATORY (Los Angeles and Canoga Park, California). Fields of interest include: physical studies of gaseous electronics, artificial meteors, reactor kinetics, microwave electronics; studies of quantum chemistry, thin film applications, electron and ion dynamics, and theoretical physics; heavy particle studies; ion propulsion research including neutralization and beam diagnostics, emitters, acceleration and ion optics, and engine design.

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ELECTROMAGNETIC SYSTEMS DIVISION (Canoga Park, California). The Radio Physics and Signal Equipment Laboratories of this division are engaged in developing advanced communication, radio direction finding, electro-optical, and penetration and reconnaissance systems; and in investigating advanced signal processing, electronic and anti-submarine warfare techniques.

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In the face of the current Pentagon decision to keep the North American B-70 bomber program limited to four prototypes, top DOD officials concede that some manned vehicle will have to be bought to replace the B-52 when it becomes obsolete.

Even Defense Secretary Robert S. McNamara, the man directly responsible for the B-70 cutback and the demise of the nuclear-powered Convair NX-2, is convinced of this requirement. Says McNamara, "We plan to explore the possibility of developing other manned systems better adapted to an operational environment in which both sides have large ICBM forces."

"STAND-OFF LAUNCHER," SAYS McNAMARA

He reports the new plane would be "a type of aircraft that might be thought of as a mobile launching platform for certain types of missiles, such as a variation of Skybolt—a stand-off launcher, if you will, that could be maintained in the air for long periods and, therefore, would not run the risk of being destroyed on the ground. Nor would it penetrate the airspace over the target in the way the B-70 would have to penetrate, but would avoid the B-70's risk of air defense losses."

The Defense Secretary concedes that the new airplane would have to be much slower than the 2000-mph B-70. "I am not talking of a Mach 3 or Mach 4 bomber," he states.

EIGHT MAJOR SUBCONTRACTORS ON DYNA-SOAR

The Dyna-Soar, which will be boosted into orbit by a Martin Titan II prior to its skip-glide re-entry into the atmosphere, will be the product of eight major Boeing subcontractors, who will make a total of about $40 million:

- Chance Vought—nose cape made of ultra-high-temperature ceramic;
- Electro-Mechanical Research—airborne and ground test instrumentation subsystem for data collection and processing;
- AiResearch Manufacturing, Los Angeles—hydrogen cooling system to absorb heat extracted from crew and equipment compartments;
- Minneapolis-Honeywell's Aeronautical Division—electronic flight control system with automatic and manual modes;
- Sundstrand—hydrogen-oxygen accessory power unit to power the Dyna-Soar generator in flight;
- Thiokol Chemical—solid acceleration rocket usable for either escape in case of trouble or for propulsion after burnout of the Titan II's last stage;
- Thompson Ramo Wooldridge—reaction control power components to stabilize and control the vehicle when aerodynamic controls are not fully effective.

The National Aeronautics and Space Council, which was largely dormant under Eisenhower, has emerged as a strong influence on President Kennedy. With Vice President Lyndon B. Johnson as chairman and Sen. Stuart Symington's former assistant, Dr. Edward C. Welch, as its director, the Council has told Kennedy what is required for the U.S. to catch up with the Russians in space.

Welch told SPACE/AERONAUTICS that the council, made up of the Vice President, Defense Secretary Robert McNamara, Secretary of State Dean Rusk, NASA Administrator James E. Webb, and AEC Chairman Dr. Glenn T. Seaborg, will be backed by a staff of 18-20. It will have no definite schedule of meetings—the members will get together as the occasion warrants.

AEROSPACE INDUSTRY CONSULTED BY SPACE COUNCIL

Before their recommendations to the President for the augmented space program for fiscal 1962, the Vice President and Welch consulted not only with the Budget Bureau but also with the aerospace industry. The same procedure will be followed in the future. Welch says his door is open to anyone from industry who has a worth-while space proposal—but emphasizes the Space Council is not in the hardware-buying business.

Welch and the Vice President are reluctant to indicate how much of the new Kennedy space proposal originally came from them, but actually the President bought their entire package, including acceleration of nuclear rockets, modifications of Apollo for lunar landings (instead of lunar orbits), backup of Nova's liquid upper stages with DOD-sponsored work on solid rockets, and substantial new funds for R&D on the earth's environment.

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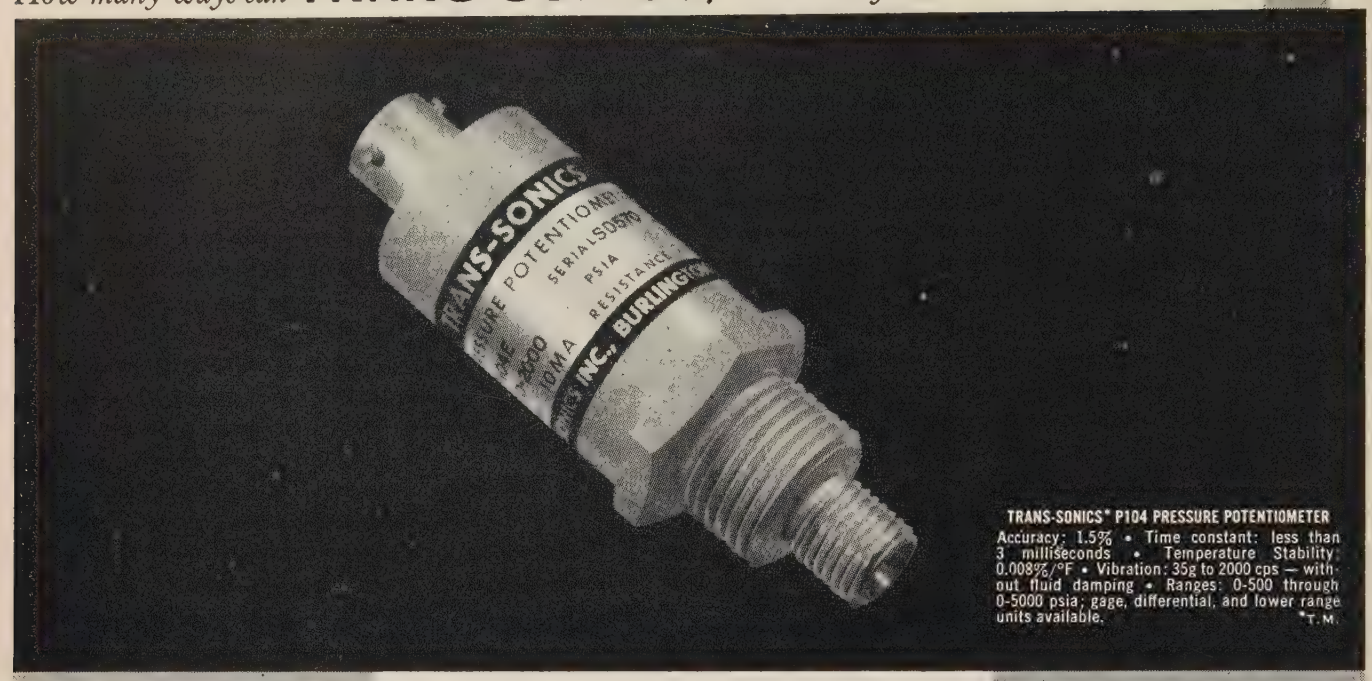

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INDUSTRY BRIEFING

ENVIRONMENT SIMULATOR FOR FULL-SIZE SPACECRAFT

The outer-space simulator now building at General Electric's growing Space Technology Center, Valley Forge, Pa., will be a major part of the Space Environment Simulation Lab there. It will simulate pressure and temperature conditions.

In overall charge of GE's new space simulator is Logan B. Cowles, manager of engineering for the Company's Missile & Space Vehicle Department, (MSVD) in Philadelphia.

Cowles has been with GE since graduating from Montana State College in 1937, where he earned his BS in ME. He's been active in GE missile and space programs since 1950, when he joined what was then the Guided Missiles Department as manager of product engineering. Later, when the department was working on the Hermes family of missiles for the Army, he was named manager of frame and auxiliary design. Cowles has been with MSVD since it was formed in the mid-1950's and was manager of nose cone engineering before taking his present post.

Says Cowles, "The simulator will allow GE engineers to test full-size space vehicles and their equipment in accessible locations and under controlled conditions before actual space launchings."

The cylindrical pressure vessel will be 32 ft in diameter and 54 ft high, and will test vehicles as big as 20 ft and weighing as much as five tons for as long as 200 hours. The building housing the simulator is 88 ft high and 100 ft square.

The Space Environmental Lab is expected to be in limited use this year and completed by mid-1962. The big GE Center reflects the importance the company places on the growing space market. This market, says A. W. Robinson, MSVD's manager of space business development, will increase "from $1 billion a year in 1960 to $8 billion in 1970."

Logan B. Cowles

TEST EQUIPMENT FOR DYNA-SOAR

D. M. Powers

A major test equipment subcontract worth several million dollars was awarded to Electro-Mechanical Research, Sarasota, Fla., by Boeing. The Florida firm will provide airborne equipment for collecting and preparing Dyna-Soar test data and will develop ground equipment for receiving, displaying, recording, and processing the data.

The airborne equipment will include PCM and FM conversion equipment, a time-coded generator, and a tape recorder. Test data will be transmitted to the ground via a link that RCA is developing as an associate contractor on the Dyna-Soar program.

Electro-Mechanical Researcher's Dyna-Soar test instrumentation program will be directed by D. M. Powers, general manager of the company's Systems Division. "We expect to strengthen our present Dyna-Soar project staff by adding several technically qualified engineers," Powers told SPACE/AERONAUTICS. "EMR particularly is interested in engineering people with very strong backgrounds in telemetry, systems management, and instrumentation systems," he added.

All divisions of EMR, including Ascop, in Princeton, N. J., contributed to work leading to this contract. The initial phases of the contract involve only design and engineering, which will be performed over a three-year period in existing facilities, Powers explains.

Powers has been in electronics management and engineering for 20 years. He received his Bachelor's and Master's degrees in electrical engineering from MIT and worked on radar, microwave components, and magnetrons for Raytheon during World War II. Later he joined Melpar, doing applied research in bandwith compression, advanced radar, and other fields.

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Dr. Elias Snitzer

Development of a sun-powered laser has started at American Optical, Southbridge, Mass., under Air Force contract. The laser will be used for communication with satellites and other spacecraft.

The $89,085 research project is under the direction of E. O. Dixon, chief electronics engineer at American Optical's Research Center. "Use of a sun-powered laser," Dixon explains, "will give a highly directional, jam-free device for space communications. It will make possible transmission over immense distances, and at the same time probably require little power."

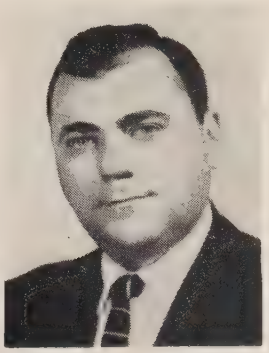
The laser will be a pink ruby rod with partially reflecting ends and will use flash tubes as power sources. The green and blue light from the flash tube excites the chrome ions in the ruby. The atoms then reradiate red light, some of which is trapped and bounced back and forth between the end reflectors. This trapped light causes further emissions to be in phase and so builds up a high-intensity beam.

"By using a large solar collector," Dr. Elias Snitzer, chief physicist on the project, explains, "a large supply of green and blue light can be produced to cause the ruby rod to go into continuous laser oscillation." He adds that "use of the sun as a power source will simplify the unit and provide a long-lived, self-contained communications system."

Dixon graduated from the University of Nebraska with an electronics engineering degree. He worked for Eastman Kodak for 10 years before joining American Optical's Research Center in 1954 as head of the electronics section, which is now completing development work on a target detecting device for the advanced Sidewinder.

Dr. Snitzer received his BS in electrical engineering from Tufs in 1945 and added an MA and Ph.D. from the University of Chicago in 1953. He was a research physicist for Brown Instrument, Philadelphia, and associate professor in the Electronics Engineering Department of the Lowell (Mass.) Textile Institute before joining American Optical in 1959. His current fields are dielectric waveguides, antenna theory, fluorescence, and solid-state physics.

THERMOELECTRIC CONVERTER FOR SNAP PROGRAM



Melvin Barmat

A contract to develop a thermoelectric converter for the Snap program was awarded to General Instrument's Thermoelectric Division by NAA Atomics International. The converter is to be used as part of an experimental compact reactor system designed to produce auxiliary power for spacecraft.

In charge of the converter work is Melvin Barmat, manager of Thermoelectric. A physicist-engineer, Barmat joined General Instrument in 1959. Before that he'd spend six years at Martin as project manager for Snap-3. Earlier he had been senior electronics engineer and project engineer on missile developments.

Before joining Martin, he was with Chatham Electronic. He's a graduate of Hofstra, attended Cooper Union's School of Engineering, and has done graduate work at Brooklyn Polytech.

If the problems of operating a thermoelectric converter in a nuclear space environment are solved, Barmat says, such a converter—coupled with a nuclear reactor—might be the forerunner of a family of nuclear space power systems of considerable size and usefulness. "These thermoelectric systems should give extremely high reliability and dependability for long periods," he declares. It may be possible, he points out, to operate the systems in the Van Allen belt, where the high doping levels of thermoelectric materials won't be adversely affected.

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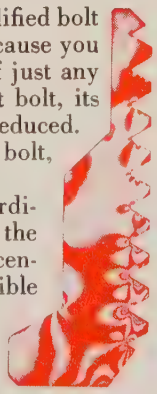
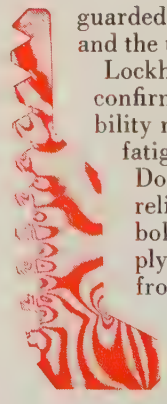
When you specify a high-tensile fatigue qualified bolt for a high-stress application, it's usually because you want to insure a reliable connection. But, if just any ordinary high-tensile nut is applied to that bolt, its reliability under dynamic loading may be reduced. It may perform no better than an ordinary bolt, despite the price paid for greater reliability.

The stress photos here show why. In an ordinary locknut the load is concentrated on the lower three threads of the nut. This load concentration can accelerate bolt fatigue—and possible failure. But with an ESNA Double/Durability* nut—featuring the revolutionary EQUA-STRESS thread pattern—the stress load is re-distributed over *all* the threads. The reliability of the bolt is safeguarded because the bolt is more uniformly loaded and the unit load per thread is reduced!



OLD



NEW

Lockheed engineers design for reliability, and tests confirmed ESNA data showing that Double/Durability nuts could be depended upon to increase the fatigue life of the JetStar power plant attachments.

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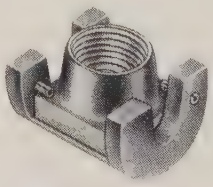
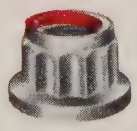
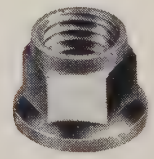
LH3393T, (220,000 psi)
LHEB220T, (220,000 psi)



LH2577T, (180,000 psi)
LH3220T, (220,000 psi)



EBT,(180,000 psi)



LH3489T, (180,000 psi)

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DUAL-JACKETED 35-FT-DIAMETER TANKS HOLD 90,000 GAL OF LIQUID HYDROGEN EACH

Two liquid hydrogen storage tanks, claimed to be the nation's largest spherical tanks, were installed at Douglas' Sacramento Calif., test facility as part of the Saturn S-IV program. The tanks, each of which will hold 90,000 gal, are 35 ft in diameter. Dual-jacketed, they have an inner skin of aluminum plate and an outer one of steel. The 2½-ft space between the walls is filled with 60,000 lb of expanded volcanic silicate insulation, which is expected to limit the evaporation loss to 0.013 per cent per day.

Convair 990 achieved Mach 0.97 at 22,500 ft over the Pacific between Santa Catalina Island and San Diego last month, Convair announced. Test pilot Don Germeraad stated that flying the craft in this speed range "was as easy as flying earlier jet transports at much slower speeds"—thanks to four aerodynamic anti-shock bodies on the upper wing surfaces. It was also claimed by Convair that, in the critical q-range of aerodynamic stress, the 990 flew faster than any other airplane: 462 knots IAS (640 mph TAS) at 14,000 ft.
Test flights have shown that earlier 990 problems at high speeds were solved by design changes that shifted the position of the outboard engine pods. FAA certification for Mach 0.91 flight is expected before the end of this year.

First successful manned flight of the Army's Rogallo flex-wing test bed was announced by Ryan Aeronautical's Ryan Aerospace Division. Based on pioneering work by NASA's F. M. Rogallo, the plane is powered by a 100-hp Continental pusher engine. Its body consists of a platform on a fixed four-wheel landing gear and with the pilot forward and the engine aft. Its span is 39.4 ft; the fully deployed area of the wing, which has an arrow-shaped platform, is 555 sq ft. The keel and leading-edge members of the wing are 28 ft long.

STABLE ABOUT ALL AXES

The flex wing is said to be inherently stable about all axes because of self-righting, or the "pendulum effect," created by the position of the suspended mass well below the lifting area. The flight path is controlled by shifting the CG with respect to the wing CP. (See also S/A, Engineering Intelligence, Apr. '61, p. 32.)

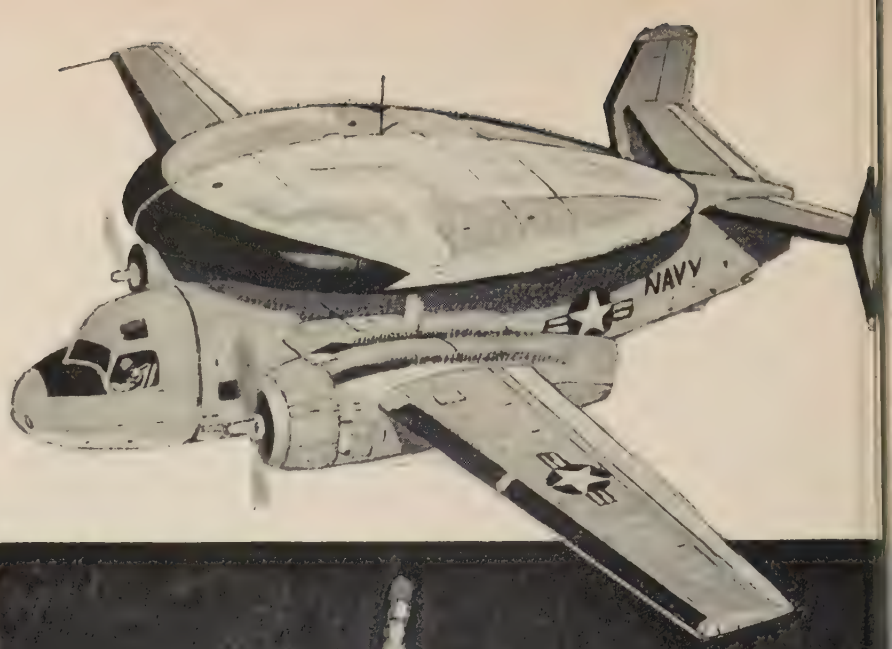
EXPENDABLE MACH 2 TARGET FOR 5000-70,000 FT

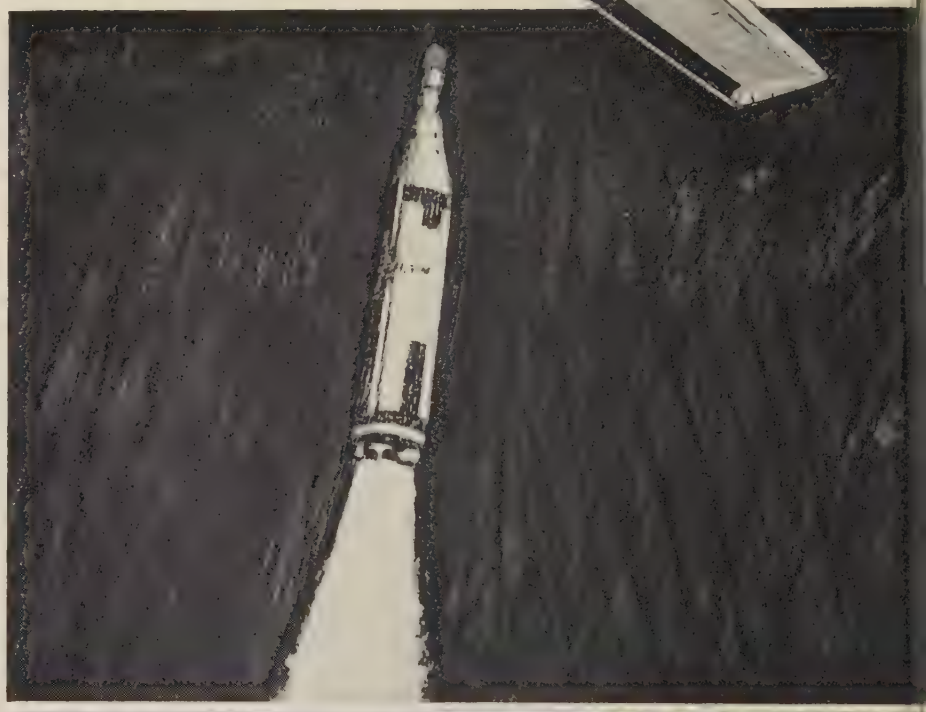
Expendable supersonic training target was successfully launched for the first time at Naval Missile Center, Pt. Mugu, Calif. Capable of level flight at any predetermined altitude from 5000 to 70,000 ft at Mach 2, the XKD2B-1 target will become operational in late '62. It is powered by a Rocketdyne liquid-propellant engine that produces over 600 lb thrust and is five inches wide, nine inches long, and weighs 17 lb. It uses MAF-4 hydrazine-based fuel with RFNA oxidizer. The target is the result of a joint Navy-USAF R&D effort, with the BuWeps acting as project manager and Beech Aircraft as prime contractor.

Venus radar bounce tests have yielded the most accurate yardstick yet calculated to measure distances in the universe, NASA's Jet Propulsion Laboratories reported. Using its Goldstone facility, JPL succeeded in making daily contact with Venus at 2388

THE WONDER MATERIAL OF THE SPACE AGE IS PLASTICS

...AND THE COMPANY FOR PLASTICS IS ZENITH





From giant radomes... to radar antenna reflectors... to missile cases... to marine craft components... Zenith has the versatile capability to produce it *better* in plastics.

For more than 15 years, Zenith has pioneered new techniques and production processes in plastics. Today, Zenith has the most completely equipped reinforced-plastics laboratories and the most complete electronic test facilities for reinforced-plastics components in the world.

Zenith's production facilities include not only the usual plastics production equipment, but special equipment such as giant lathes, one of which is a hundred feet long. With equipment such as this, plus a wealth of engineering competence for design, tooling, fabrication, and testing, it is no wonder Zenith was called upon to make the giant radome for the Navy's Constellation, the largest airborne radome ever built. This is also why Zenith is making the tough plastics liner for the Polaris missile container.

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3M COMPANY

mc from March 10 through May 10.
JPL announced a value of 92,956,000 ± 1000 miles for the astronomical unit (AU), the scale factor of the universe. Refinement of data is expected to reduce the uncertainty of the AU to ±100 miles by the end of June. The tests also showed that Venus rotates very slowly—perhaps only once every 225 days, which is the length of the Venusian year.
Dr. Eberhardt Rechtin, director of JPL's Deep Space Instrumentation Facility, said the new test data will prove highly important for probes sent to Venus and other planets. "Up until now," he said, "we have not known the position of the planets to any great accuracy because of uncertainty in the AU. . . . Another uncertainty, the unknown reflection properties of the surface of Venus, previously made design of spacecraft radars almost impossible. This uncertainty has now been removed. A determination of the slow rotation rate of Venus also reduces the uncertainty of landing on the surface."

Design studies of multiple-satellite-launching boosters were discussed at the recent First National Conference on Peaceful Uses of Space, at Tulsa, Okla. NASA officials noted that such boosters would cut the cost of a system involving many satellites (e. g., Transit). The first multiple-launch test is slated for next year, when three satellites will be launched into a 1700-mile orbit. In '63, six satellites are to be launched by a Centaur booster.

SATURN'S S-IV STAGE WITH FAIRINGS COULD BE TRANSPORTED BY C-133, DOUGLAS CLAIMS

Piggyback transportation of the Saturn C-1's second stage on top of a Douglas C-133 turboprop transport was discussed at the Tulsa meeting by Dr. Wernher von Braun, who revealed that the use of dirigibles and gliders is also under study. Douglas has proposed that lightweight fairings be attached to the front and rear of the S-IV stage to minimize drag. With fairings, the S-IV would be about 68 ft long. (Its engine alone is 41 ft long and 18 ft in diameter.)

Air transportation, C. R. Strong, of Douglas, points out, would take a considerably less time than the combination of barge and ship originally scheduled to carry the stage to Cape Canaveral, Fla.—flying from Sacramento, Calif., would take 10 hours as against 24 days by barge and ship.

NASA-Douglas wind tunnel tests show that the piggyback method is feasible. To do the job, the C-133 would have to have minor tail section modifications for added directional stability. One proposal calls for adding vertical surfaces at the tips of the horizontal surfaces.

Tests of the J93 turbojet engine, which will power the B-70 Mach 3 bomber, are slated to start soon at GE's ram test facility, which simulates Mach 3, 60,000 ft altitude inlet conditions, and at Arnold Air Development Center, Tullahoma, Tenn. W. F. Cronin, manager of GE's Flight Propulsion Division, states that J79 design experience has been drawn on heavily in the J93 program. Like the J79, the J93 uses variable-incidence stators in the compressor to control the high velocity air flow enough so that a single spool-rotor and three main support bearings can be used. The J93 also retains the J79's converging-diverging exhaust nozzle. Controls and accessories are located in a removable pod under the compressor section.

165,000 LB THRUST FOR NEW THOR BOOSTERS

New Thor production ordered from Douglas for additional USAF Discoverer, Navy Transit, and NASA Nimbus shots will be based on the more powerful Block II engine, which provides 165,000 lb thrust, as against 150,000 lb for the earlier Thor

ten-ton muscles at Mach 2 . . . call for actuators with inherent reliability. Such failproof performance has long been characteristic of Ex-Cell-O hydraulic, pneumatic and mechanical rotary and linear actuators. ■ Equally reliable fuel controls, nozzles, metering systems, compressor blades, wheels and other precision powerplant, airframe and GSE components are also produced by Ex-Cell-O in quantity. ■ Ex-Cell-O facilities include prototype design and testing; highly developed techniques for machining and fabricating modern metals; in-plant heat treatment; and inspection and quality control procedures specifically suited to the production of precision hardware for the fields of aircraft, missiles and atomics. ■ Contact our Representative in your area, or write direct for detailed information.

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versions. The advanced DM-21 Thor is the result of over 400 changes and modifications since the original DM-18, Douglas says.

DM-21 THOR SAVES 1180 LB

The total weight reduction achieved by all these changes is 1180 lb. Some 400 lb in airframe weight was saved by shortening the upper transition section by 5½ ft after elimination of the all-inertial guidance unit used in tactical Thors, and relocation of the battery and inverter used to power the flight controller.

The fiberglass tunnels running from the transition (guidance) section of the engine section have been replaced by lightweight aluminum tunnels. The engine section structure was strengthened to take the Block II engine, as was the tank section bulkhead.

CONTINUED USE OF COPTERS FORESEEN BY NASA RESEARCHERS IN REVIEW OF V-STOL FIELD

V-STOL prospects were reviewed at National IAS-ARS Joint Meeting in Los Angeles by M. W. Kelly and C. A. Holzhauser, of NASA. While the top speed of copters is limited by advancing-blade compressibility losses and retreating-blade stall, many studies have shown that significant improvements in range and/or economy are possible, the NASA researchers stated. Studies also show that significant reductions in vibration may be possible. Kelly and Holzhauser concluded that the transport copter will continue to be used—at least for short-range missions.

VTOLs FOR MEDIUM RANGES

For medium-range missions, for which speed and aerodynamic efficiency are more important, the compound helicopter and the low-disk-loading tilting rotor can provide significant improvements in aerodynamic efficiency while retaining most of the favorable low-speed operational characteristics of the copter. For flight speeds of over 300 knots, higher-disk-loading V-STOL craft are indicated, mainly because of structural and aeroelastic considerations, the NASA researchers said. This is particularly true for high speed at low altitude—needed, for instance, for military assault transports, which must avoid radar detection and enemy fire. For this type of mission the high-disk-loading, high-wing-loading ducted-fan configuration seems to hold great promise. However, the high speeds of any high-disk-loading configuration are accompanied by large hovering power requirements, hovering fuel consumption, and hovering downwash velocities, which could comprise the overall usefulness of such a craft.

For missions for which hovering isn't essential, Kelly and Holtzhauser reported, STOLs could provide marked payload or range increases over VTOLs.

A cesium-vapor thermionic converter that can be produced reliably and in quantity for spacecraft and other special applications was announced by GE's Power Tube Department. The sealed converter has produced 23 W at a cathode temperature of 1530 deg C—equivalent to 4.6 W/cm² for a 15-17 per cent efficiency. The device gives 10 W at 2.4 W/cm² and 11 per cent efficiency at about 1300 deg C cathode temperature.

GE's Dr. A. O. Jensen states that such converters with a useful life of 10,000 hours of steady operation are in sight. He says that, when tube seal temperatures can be kept below about 500 deg C, such operation is possible right now.

GE is also developing a triode vapor thermionic converter with a grid in the cathode sheath. Dr. Jensen states that this converter offers power densities of four W/cm² at about 20 per cent efficiency and a cathode temperature of 1327 deg C. It works on an electron injection principle.

Cesium-filled thermionic converters also produce significant amounts of AC in the radio frequency range (from 30 kc to one megacycle), while giving their major output in the form of DC. The phenomenon was reported by General Atomics scientists last year. Under contract to Rome (N.Y.) Air Development Center, they are now studying the conditions under which the cesium-vapor cells produce AC during the direct-conversion process, with the emphasis on the possible production of RF at 50 mc or higher.

HOW MANY PLANES ARE THEY TALKING ABOUT?

"As a tactical strike aircraft in support of ground troops, it can whisk in with rockets, a 20mm cannon that fires at a rate of 6000 rounds per minute and a bomb bay packing a heavier load, either conventional or nuclear than a World War II B-17 bomber . . . ." **Time**

"The plane . . . has the versatility to perform alternately as an interceptor, fighter or high-speed refueling plane . . . ." **New York Times**

"The one-man bombers . . . can provide combat flexibility and observation capability . . . ." **Flying**

"In effect, a reusable guided missile . . . . . ." **Interavia**

ONE!

THE F-105 THUNDERCHIEF

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REPUBLIC
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AEROJET CLAIMS TO HAVE WORLD'S MOST POWERFUL SEGMENTED SOLID ROCKET MOTOR

The half a million pounds of thrust generated by Aerojet-General's three-segment solid rocket make it the most powerful engine of its kind in the world, according to the company. The motor consisted of segments joined together just before firing. It was 30 ft long, had a diameter of 100 in., and weighed 110,000 lb. Dan A. Kimball, Aerojet's president, said that the test firing proved that rocket power can be tailored to payload requirements by adding or subtracting segments.

Tory IIA-1 test reactor for a nuclear ramiet was operated for 45 seconds at about 25 per cent of its design power. Flight conditions were simulated by forcing air at 360 psi through the reactor. This was the first power test for the AEC-AF Project Pluto, designed to provide a powerplant for a crewless ramjet bomber cruising at Mach 3 for indefinite periods under remote control. The design output level is 150 thermal Mw.

SATURN TEST SCHEDULE CHANGED BY NASA

Modification of the Saturn's S-IV second stage and a planned increase in the propellant capacity of the S-I booster stage have caused changes in the NASA test program for the vehicle. The S-IV will use six 15,000-lb-thrust P&WA LR-115 liquid-hydrogen motors instead of the four larger LR-119s, for a total thrust increase from 70,000 to 90,000 lb. Starting with the seventh flight, the S-I stages will have tankage for 100,000 lb of extra propellants and use the H-1 engines at their design thrust of 188,000 lb.

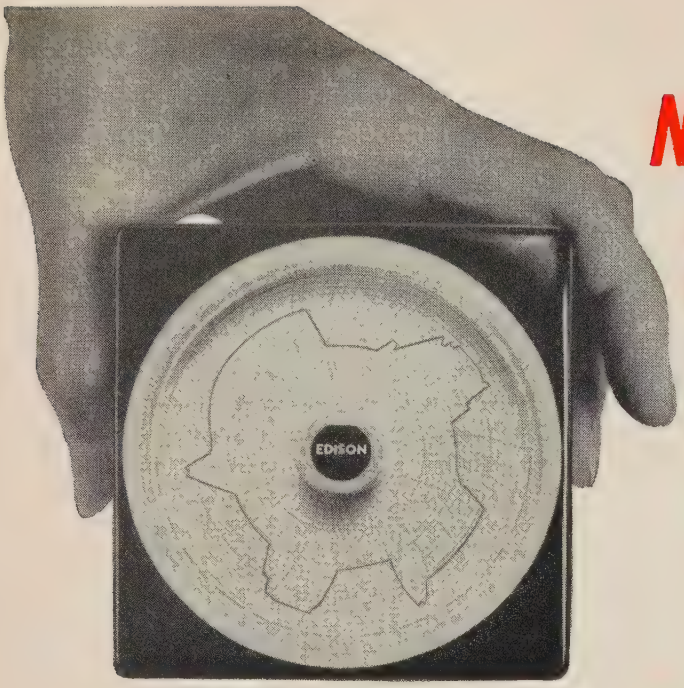
TEN FLIGHT TESTS ARE TO BE MADE

Present plans are for a ten-flight vehicle test program. The first three Saturn C-1s will have live boosters and dummy second and third stages. The next three flights will be made by a vehicle using the live S-I and S-IV stages. Flights 7-10, which may be used to put boilerplate models of the Apollo capsule into orbit, will use the same stages. The overall length of the last four vehicles will be reduced by a shorter instrument-compartment payload-adapter section. Tail fins will be used on the booster for better stability and control.

The S-V third stage, with two LR-115 motors of the original Saturn C-1 configuration, will not be used until a later phase of the C-1 program and in the Saturn C-2. The two-stage C-1 will be able to put about 10 tons into a low earth orbit, just about the same as the three-stage vehicle.

Model of a medium-range supersonic transport was exhibited by Sud-Aviation at the 24th International Air Show at Paris. This "Super Caravelle" has a wing similar to that of the Douglas A4D series and a pair of joined B-70-type nacelles of rectangular cross-section at the central trailing-edge of each wing. Estimates give a range of 2500 miles and a speed of Mach 2.2.

A denser solid propellant that "packs more wallop and occupies less space" was announced by Goodrich Aviation Products. Frank R. Carvell, general manager of the Goodrich rocket motor plant in Rialto, Calif., said the propellant is a mixture of Hycar synthetic rubber and high-energy compounds, and that development tests showed that the formula gives a 15 sec increase in specific impulse over present rubber-based propellants. The new C-123 propellant would reduce the weight and increase the thrust of rocket motors by about six percent.
The Nitro C-rubber group of compositions to which C-123 belongs is reported to be better than nitro-cellulose-type propellants in aging stability, in ballistic and mechanical properties from —110 to 250 deg F, and in bonding and handling characteristics. Carvell said that the propellant would be used in anti-aircraft missiles, upper vehicle stages, and high-mass-ratio motors for space probes and satellites. Flight hardware will be demonstrated this year.



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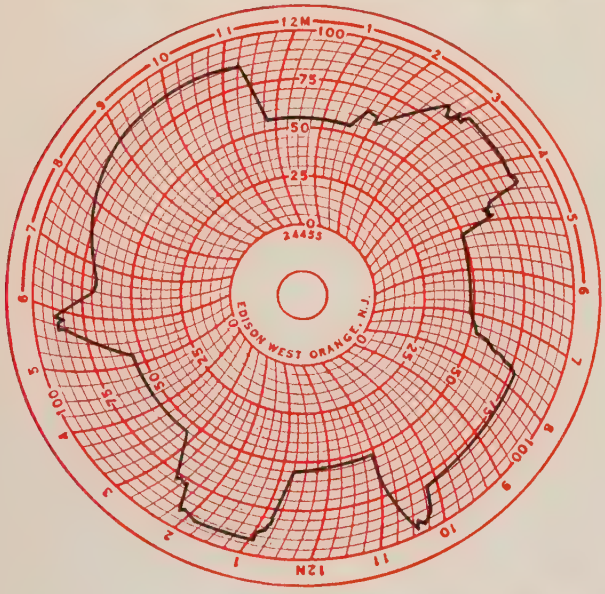

- INEXPENSIVE
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Now you can take advantage of a new, economical means of recording any variable that can be converted to an electrical signal. Thanks to Omnicorder, you need no longer rely on meters or indicators, even where cost factors or space restrictions would ordinarily dictate the use of these instruments.

Measuring just 3¾″ x 3¾″ x 3″, Edison's Omnicorder, a unique circular chart recorder, is so compact that nine units occupy just one square foot of space. Thoroughly legible, yet requiring no ink, pen or ribbon, Omnicorder is equipped with a simple three-speed adjustment which regulates chart rotation, thereby providing time sequences to meet varied needs. A flick of the switch gives users a choice of these sequences: one hour, seven hours and thirty hours per revolution — or one day, seven days and thirty days per revolution.

Omnicorder's simple, inexpensive construction assures dependable operation and a long, maintenance-free life. Four types of meter movements are available to measure a wide range of AC and DC electrical quantities, ranging from thermocouple outputs to currents as high as 100 amperes. No amplification is ever required, even for signals as low as 10 microamps.

For complete information on this rugged, maintenance-free Omnicorder, write for Catalog 3057.

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Zero Set Screw: Adjustment is made when measuring system is not printing and when the circuit to be recorded is disconnected.

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CALENDAR

JULY

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AUGUST

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SEPTEMBER

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July 13-16 Third Annual Industry Missile & Space Conference & Aerospace Exposition, Michigan Aeronautics and Space Assn., Cobo Hall, Detroit, Mich.

July 16-21 Fourth International Conference on Bio-Medical Electronics, Institute of Radio Engineers, Waldorf Astoria, New York, N. Y.

July 24-26 Air Traffic Control Facilities Symposium, Electronic Maintenance Engineering Assn., Mayflower Hotel, Washington, D. C.

July 25-Aug. 10 International Trade Fair & Aviation Exhibition, McCormick Place Exposition Center, Chicago, Ill.

July 31-Aug. 4 International Symposium on Non Linear Differential Equations & Non Linear Mechanics, Air Force Academy, Colorado Springs, Colo.

Aug. 1-3 Fourth Western Regional Meeting, American Astronautical Society, Sheraton-Palace Hotel, San Francisco, Calif.

Aug. 15-17 Cryogenic Engineering Conference, U. of Michigan, Ann Arbor, Mich.

Aug. 16-18 International Hypersonics Conference, American Rocket Society, Massachusetts Institute of Technology, Cambridge, Mass.

Aug. 19-24 Institute of the Aerospace Sciences, Naval Aviation Meeting, San Diego, Calif.

Aug. 27-30 Symposium on the Solar Corona, Sacramento Peak Observatory, Sunspot, N. M.

Sep. 4-10 1961 Flying Display & Exhibition, Society of British Aircraft Constructors, Farnborough, England.

Sep. 6-8 National Symposium on Space Electronics and Telemetry, Institute of Radio Engineers, U. of New Mexico, Albuquerque, N. M.

Sep. 20-24 National Convention & Aero-Space Panorama, Air Force Assn., Philadelphia, Pa.

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Space programs and basic research boosted by

USAF PROCUREMENT management has been completely streamlined as of July 1. Involved is the reshuffling of several billions of procurement dollars between two major commands, the raising of basic and applied research to a status equal to that of systems development, the upgrading of the USAF space mission onto a level with ballistic missiles, and the exchange of some 14,000 "hats."

Unchanged are USAF procurement procedures, the people handling contracts, and the physical locations of their desks at Wright-Patterson AFB, Ohio, Andrews AFB, Md., and other USAF procurement offices.

A casualty of USAF's general spring house-cleaning is the term "weapon system." People in the know now call it simply "system." It finally occurred to someone in the dim recesses of the Pentagon that, since not all systems developed for USAF are straight weapons—BMEW, for instance, is anything but a weapon in the conventional sense—the word "systems" alone is more descriptive of USAF projects.

Although procurement procedures and people remain unchanged, the organizational changes USAF has all but completed are highly significant. The ARDC has become the Air Force Systems Command (AFSC) and is now in charge of all activities leading to the acquisition of systems for the operating commands. This includes applied research, development, procurement and production as well as collateral functions like quality control, inspection, and testing. AFSC is headed up by Lt. Gen. Bernard A. Schriever, who commanded ARDC.

AMC has turned into the Air Force Logistics Command (AFLC) and handles procurement only after production has ended or at least reached a point at which no further engineering changes will be made. It will also supply spares and operate and control the world-wide logistics systems for the entire Air Force.

A complete reorganization of two major USAF commands went into effect this month. The new AF Systems Command succeeds ARDC and is in charge of the acquisition of all systems from applied research through procurement and production. The new AF Logistics Command, AMC's successor, takes over the procurement of spares and operates USAF's world-wide logistics system.

The new setup is designed for more effective management, particularly of ballistic missile and space programs. Space programs now are handled by a separate division. Although AFLC has been stripped of AMC's major procurement and production functions, procurement procedures and personnel generally remain the same.

The new Office of Aerospace Research now reports directly to the Air Force chief of staff. It is no longer tied to systems development, as it was under ARDC and probably will become a command before long.

AFSC gets $3.2 billion from AMC

As a result of the change in responsibilities, the old AMC is turning over about 30 per cent of its procurement dollars to the new AFSC—$3.2 billion for fiscal 1962 and about $2.2 billion for fiscal 1963.

The development of any aerospace system inevitably extends into the production phase. Under the old USAF setup, it often was not clear, therefore, when ARDC should let go of a program and AMC should take over. The trouble was not that the two commands refused to cooperate—it was simply that they were not sure who was in charge. To put it in Pentagonese, the shift in "executive management responsibility" (EMR) was not properly defined.

While the shift of EMR is now more clearly defined, there still are "gray areas." For example, applied research is under AFSC, if it applies to a specific system. But if it does not, it may be under the Office of Aerospace Research (OAR), a new USAF agency that reports directly to the chief of staff. Another exception to the new ground rules concerns the final production of systems that need no further major modification, like the B-52H. In such cases, AFLC may eventually be put in charge to relieve AFSC.

One of the basic goals of the reorganization was to enable USAF to "do a more effective management job

by **Randolph Hawthorne,** Editor

AF reorganization

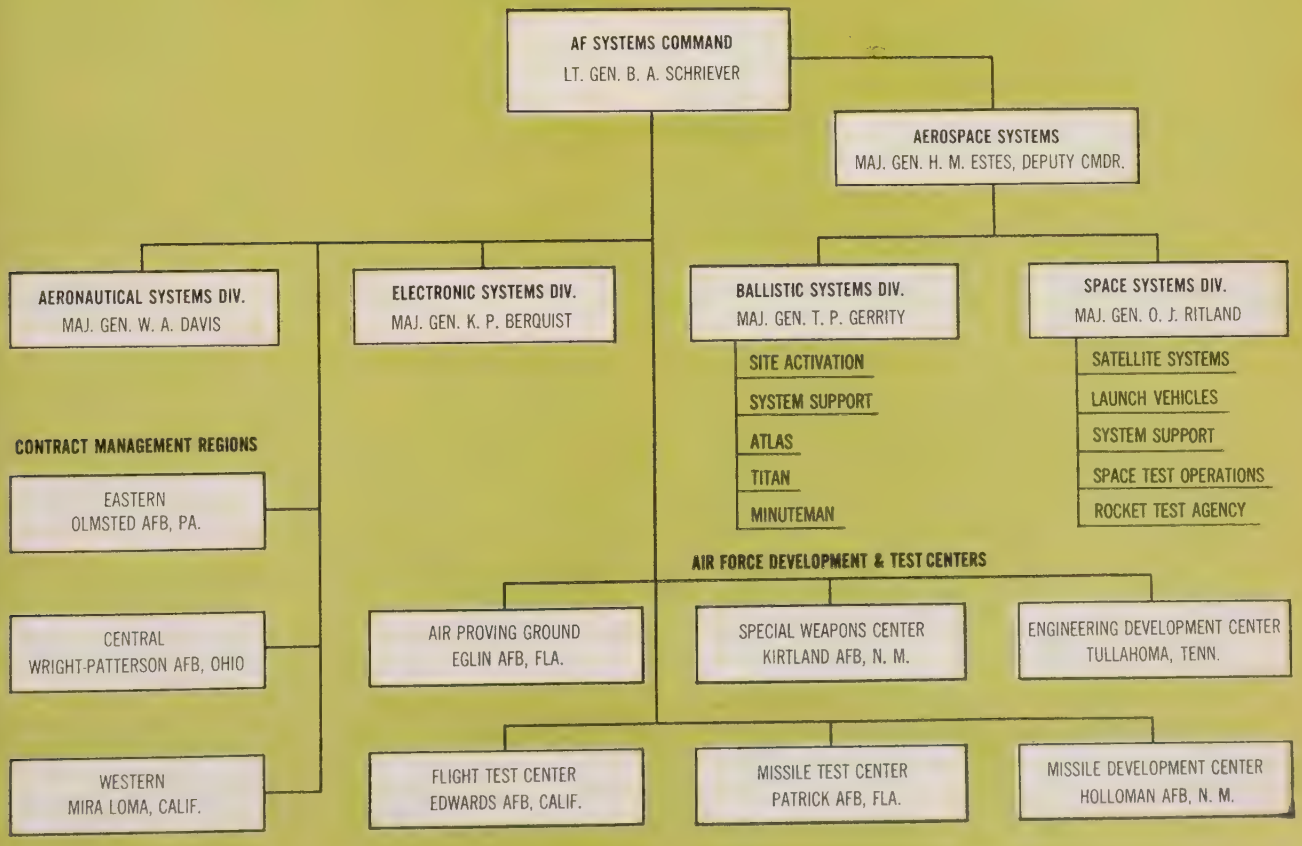
on our ballistic missiles and our space systems," as Air Force Secretary Eugene Zuckert puts it. The space systems in particular needed a management set up of their own. Also badly needed was a closer relationship between USAF and the Army Corps of Engineers on missile site activation work.

The reorganization also brought some changes in USAF's setup for ballistic missiles. Formerly, ARDC's Ballistic Missiles Division (BMD), AMC's Ballistic Missiles Center (BMC), and the Army Corps of Engineers shared the responsibility for each ballistic missile. A cleaner, more straightforward management setup was needed, providing straight-line command from top to bottom.

BMD has been split into the Ballistic Systems Division (BSD) and the Space Systems (SSD)—a boost in status for the space mission. Both divisions are under AFSC's deputy commander for aerospace systems.

BSD is composed of elements of the old BMD and BMC, and of the Engineer's Ballistic Missile Office, which is in charge of base construction. General A. C. Welling, who commands the Ballistic Missile Office, has

NEW AF SYSTEMS COMMAND replaces ARDC and takes over systems production from AMC—it is in charge of system acquisition of applied research through production.



been put under the operational control of BSD commander Maj. Gen. Thomas P. Gerrity (who formerly commanded BMC). For administration and support he still is under the Army. As Gerrity's deputy for site activation, Welling has both Army and AF personnel under him—all those concerned with base design and construction and the initial installation of systems.

The Air Force, incidentally, has its own Directorate of Civil Engineering, which corresponds in a fashion to the Army's Corps of Engineers and the Navy's Bureau of Yards and Docks. The AFDCE, however, merely acts as an intermediary on construction requirements. It is limited by the 1947 military reorganization act, which ruled out any rival to the Corps of Engineers.

Heading up the new Space Systems Division is the former BMD commander, Maj. Gen. Osmond J. Ritland. His division includes groups handling satellite systems, launch vehicles, system support, space test operations, and rocket testing.

Besides BSD and SSD, the major elements of AFSC are the Aeronautical Systems Division (ASD), at Wright-Patterson AFB and the Electronics Systems Division (ESD), at Hanscom Field, Mass.

ASD, commanded by Maj. Gen. Waymond A. Davis, who headed AMC's Aeronautical Systems Center at Wright-Patterson, combines this Center with the former Wright Air Development Division of ARDC. ESD is headed by Maj. Gen. Kenneth P. Berquist, fomerly commander of ARDC's Command & Control Development Division, which is now combined with the AMC Electronics Center in the new AFSC division.

Each of the four AFSC divisions will manage the acquisition of systems. For this purpose, each will have all the management resources needed for the development, test, evaluation, procurement, and production of systems and for the planning of support and operation.

In addition, each division will include representatives from the operating commands (SAC, TAC, MATS, and the Air Training Command). When a division does work for the Army, the Navy, or NASA, these organizations, too, will supply representatives.

AFSC also takes over all the old ARDC's test and development centers: the Special Weapons Center, Kirtland AFB, N.M.; the Engineering Development Center, Tullahoma, Tenn.; the Missile Test Center, Patrick AFB, Fla.; the Missile Development Center, Holloman AFB, N.M.; the Test Center, Edwards AFB, Calif.; and the Air Proving Ground, Eglin AFB, Fla.

The biggest organizational change hit the old AMC on April 1. On that date, about 14,000 people took off their AMC hats and became AFSC people. In fact, a switch of hats was almost literally all that happened—there have been, and will be, few physical transfers. Only a limited number of personnel (both military and civilian) will actually change jobs.

At the Pentagon level, Zuckert points out, there will have to be some "realignment of responsibilities between the research assistant secretary and the materiel assistant secretary." But this change won't affect procurement procedures either.

Up to the time of reorganization, AMC made major procurement policy and was responsible for major procurement and production, while ARDC was responsible for R&D up to the point of production. Now the procurement function has in effect been split between AFSC and AFLC.

What is OAR?

Air Force Office of Aerospace Research, Temporary D Building, Washington, D. C.
Commander: Maj. Gen. Daniel E. Hooks

Mission

All basic USAF research and development of new techniques pointing to important new military missions.

Elements

Office of Scientific Research—Supports basic research by awarding contracts to scientific community. Program based almost entirely on unsolicited proposals. Executive Director: Dr. Knox T. Millsaps.

Aeronautical Research Laboratory, Wright-Patterson AFB, Ohio—Conducts and sponsors basic research in the physical sciences. Emphasis on in-house activities. Director: Col. E. C. Mallary.

Cambridge Research Laboratories, L. G. Hanscom Field, Bedford, Mass.—Conducts and sponsors basic and applied research in broad areas of electronics and geophysics. Large in-house effort and considerable contract work. Commander: Brig. Gen. B. G. Holzman.

European Office, 47 Rue Cantersteen, Brussels, Belgium—Point of contact for European scientists interested in grants or contracts from other OAR elements.

No change for contractors, bidders

USAF's plans call for the transfer of the old AMC Contract Management Regions to AFSC by July 1, but the job may take a little longer. Meanwhile, contractors and bidders should continue to deal with the offices they have worked with before until they are advised of any changes.

The new AFLC, commanded by Lt. Gen. W. F. McKee (replacing Gen. S. E. Anderson, who headed up AMC) will have the same nine Air Materiel Areas, two Depots and two Air Materiel Forces as did AMC.

With the office of Aerospace Research now reporting directly to the chief of staff, research has gained another step up the Air Force ladder. In fact, the "Office" is only a temporary fixture—you can look for it to become a command.

OAR will handle all basic research needed to advance systems generally and will develop new techniques for which AFSC will be ultimately responsible.

It directs the operations of four major groups: the Office of Scientific Research; the Aeronautical Research Laboratory, Wright-Patterson AFB, Ohio; the Cambridge Research Labs, Hanscom Field, Mass.; and a European Office in Brussels.

OAR plans to rely 99 per cent on unsolicited research proposals accomplishing its task. Mostly these proposals will come from universities.

Although much of the basic research done for USAF has been on a contract basis, grants for research have been authorized for nearly three years. They make for a more flexible arrangement, say OAR officials, than do contracts. With OAR clearly favoring grants, this type of research eventually should come to predominate over the contract method.

Spacecraft temperature control:

state of the art

by Dieter Goetze, Design Analysis Section,
Guidance & Navigation Laboratory, General Mills, Inc.*

SPACECRAFT temperature control can be done with either passive or active systems. In a passive system, the heat fluxes from the sun and the earth are used exclusively and without modification as the energy source for temperature stabilization. This method has clearly predominated to date, because of the limited amount of power available in present spacecraft systems and because of size and weight restrictions. In an active system, power sources indigenous to the spacecraft are used to provide temperature control or active means are used to control systematically the heat fluxes incident on the satellite.

To find the temperature distribution over the surface of a spacecraft, we must first establish the heat-balance equation for a small area on the surface for a particular moment in time. This equation must take into account the contribution of both radiation and conduction to the supply of thermal power to the area segment. Once it is solved for its dependence on time, the solution is extended over the entire surface of the satellite.

Using the vector terms defined in *Figure 1,* the heat-balance equation at a particular instant of time for a particular area segment is:

$$(1)\quad \alpha P_s + \alpha P_a + \epsilon P_e - \epsilon\sigma T_n^4 + \frac{1}{dA}\sum_m \frac{k_m}{d_m} q_{mn}(T_m - T_n) = (m_n/dA)C(dT_n/dt).$$

* General Mills, Inc., 2003 E. Hennepin Ave., Minneapolis 13, Minn.

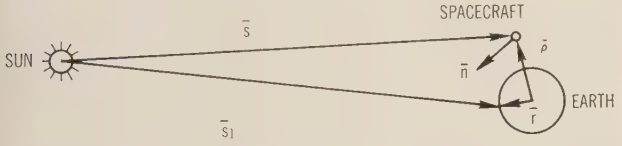
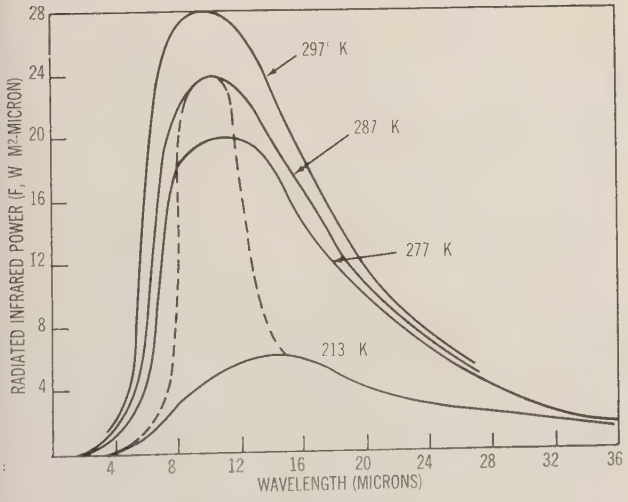


FIGURE 1: Vectors defining the sun-earth-spacecraft geometry.



BLACK-BODY radiation for various mean surface temperatures and the tropopause (213 deg K). The dashed curve shows the surface radiation that actually escapes through the atmosphere and is added to the tropause radiation.

As the number of spacecraft increases, so does the importance of the problem of spacecraft temperature stabilization. The first step in such temperature control is to find practical solutions for the heat-balance equations.

This article presents a heat-balance equation for one particular instant and one particular area segment of an orbiting spacecraft and then shows how to extend this equation over the spacecraft's entire surface. It points out that the ratio of short-wave absorptance to infrared emittance for the surface material covering the spacecraft is a key factor in developing adequate temperature control. The variations of this ratio for various types of coatings are explained, and methods of modifying it are discussed. In addition, actual coating applications on recent spacecraft are reviewed.

Nomenclature

α	reflectance of the earth, or earth's average albedo (0.34)
B	area of earth's surface over which integration is performed
B_l	sun-illuminated portion of earth's surface over which integration is performed
C	specific heat of material in segment
d	breadth
dA	area of n^{th} segment
dB	area increment on earth's surface
E_o	solar constant (1400W/m²)
E_λ	black body-monochromatic emissive power given by Planck's law for a given T
F	frequency
F_o	infrared power per unit area radiated by the earth into space (188.5 W/m²)
k	thermal conductivity
$\bar{k}_{mn}$	average thermal conductivity between m^{th} and n^{th} segments
l	running number (1, 2, 3 . . .)
m	mass
$\bar{n}$	outward normal
P_a	$\frac{\alpha F_o}{\pi} dA \int_{B_l} (s_l/s_l) \frac{(\bar{r}/r)^2 (\bar{\rho}-\bar{r})^2 \bar{n}}{(\rho-r)^4} dB$
P_e	$\frac{F_o}{\pi} dA \int_B \frac{(\bar{r}/r)\,(\bar{\rho}-\bar{r})^2 \bar{n}}{(\rho-r)^4} dB$
P_s	$E_o dA \frac{\bar{s}\bar{n}}{s}$
q_{mn}	area interface in thickness separating n^{th} and m^{th} segment
r, $\bar{r}$	scaler and vector radiuses, respectively, of earth
s, $\bar{s}$	scalar and vector distances, respectively, from sun's center to satellite's center
s_l, $\bar{s}_l$	scalar and vector distances, respectively, from sun's center to earth's surface
T	temperature at t (deg K)
t	time
α	solar-radiation absorptance of n^{th} segment
ϵ	emittance of n^{th} segment at T_n
λ	wavelength of radiation
ρ, $\bar{\rho}$	scalar and vector distances, respectively, from earth's center to satellite's center
σ	Stefan-Boltzman constant (5.672×10^{-8} W/m²-deg K⁴)
ω	$2\pi F$

Subscripts

m	m^{th} segment of satellite
n	n^{th} segment of satellite

where P_s, P_a, and P_e are instantaneous quantities in units of power per unit area. As P_s, P_a, and P_e are strongly affected by the sun-earth-spacecraft geometry and this geometry fluctuates periodically in the course of an orbital revolution, the value of *Equation 1* is different for each instant of time within a certain period. The differences depend not only on the orbital parameters but also on the season and the time of launch. This dependence makes the solution of *Equation 1* extended for a long period rather complex.

The most precise approach to the time-dependent solution of *Equation 1* is given by Camack and Edwards.[1] They represent the periodic fluctuation of the *P*-terms by a Fourier expansion, while assuming that the instantaneous temperature after the satellite has been in orbit for some time equals the sum of an average temperature and a small temperature deviation given by:

$$T_m = \overline{T}_m + \Delta T_m \tag{2}$$

As ΔT_m is assumed to be small, T_m raised to the fourth power can be represented by a binomial expansion in which all terms in ΔT_m raised to a power higher than the first are discarded.

When these expansions are substituted in *Equation 1*, the equation becomes linear in the time-dependent terms and its fluctuating and non-fluctuating parts can be separated. Once the non-fluctuating portion is subtracted, *Equation 1* emerges as a set of simultaneous linear differential equations in the fluctuating temperature term:

$$\sum_l (a_l \sin l\,\omega t + b_l \cos l\,\omega t) - 4\epsilon\sigma \overline{T}^3_n \Delta T_n + \sum_m \overline{k}_{mn}(\Delta T_m - \Delta T_n) = \frac{m_n}{dA} C \frac{d}{dt} \Delta T_n, \tag{3}$$

where the first term on the left is the fluctuating part of the Fourier expansion of the *P*-terms.

A simpler procedure is used by Goldman and Singer.[2] They assume a circular orbit with a constant height above the earth. To evaluate the time dependence of the P_s-term, they postulate an eclipse factor that is a simple step function at the moment of a satellite's entry into or emergence from the shadow of the earth. In evaluating the time dependence of the P_a-term, they make the simplifying assumption that the satellite receives reflected radiation only from the earth's surface vertically below it. The albedo radiation then fluctuates like a rectified cosine function as the satellite circles the earth.

Time in sunlight is important

For this approach, the percentage of time during which the satellite is in sunlight becomes important. This percentage is related to the orbital parameters and to the time and season of launch.

Equations 1 & 3 are valid only for the n^{th} area segment on the satellite surface. As the *P*-terms all depend on the outward normal vector (n), of this segment, the heat-balance equation can be expected to change with respect to location on the satellite surface. The total heat balance of a satellite is obtained by summing the results of solutions of *Equation 1* for the n^{th} area segment over the whole surface of the satellite.

This process is simplified if the craft rotates about an axis, for then the temperatures of the area segments tend to equalize in any plane normal to the axis of rotation. A case in point is the Explorer, a long, cigar-shaped satellite that rotates about its longitudinal axis. Solving the heat-balance equation for such a design becomes a matter of manipulating the attitude angle generated by the longitudinal axis and a fixed coordinate system.

The situation is even simpler if the attitude of the satellite remains fixed with respect to a certain sun-

(1) W. G. Camack, D. K. Edwards, "Effect of Surface Thermal-Radiation Characteristics on the Temperature Control Problem in Satellites" in "First Symposium—Surface Effects on Space Craft Materials," F. J. Clauss, ed.; Wiley ('60).
(2) D. T. Goldman, S. F. Singer, "Studies of a Minimum Orbital Unmanned Satellite of the Earth;" *Astronaut. Acta* 3/110 ('57).

earth-satellite geometry. Schmidt and Hanawalt, for example, discuss a cylinder whose axis of revolution always points toward the earth's center.[3] They distinguish between temperatures on the cylindrical surface and on the top and bottom of the cylinder. The thermal design of such a complex geometrical structure as the Tiros' takes into account the different thermal characteristics of bottom, sides and top.

The ratio of short-wave absorptance to infrared absorptance (α/ϵ) of the surface material covering a satellite is critical. If we assume that the thermal conductivity of a satellite is so great that no thermal gradients exist anywhere on the craft and that the thermal inertia of the satellite is so large that the craft's uniform temperature does not fluctuate with time, but is always in equilibrium as the satellite periodically emerges from and enters the earth's shadow, *Equation 1* reduces to:

$$\alpha P_s + \alpha P_a + \epsilon P_e - \epsilon\sigma T^4 = 0, \tag{4}$$

where T is no longer the temperature of the n^{th} segment but that of the whole satellite. By manipulating *Equation 4*, we get:

$$\sigma T^4 = P_e + \alpha/\epsilon(P_s + P_e). \tag{5}$$

Temperature can be adjusted

This equation states that the equilibrium temperature can be adjusted to any temperature above that corresponding to the thermal power input by adjustment of α/ϵ. As P_e is the thermal power input attributable to the infrared radiation from the earth, it determines the lowest possible temperature obtainable in a satellite. For a spherical satellite, this temperature is around —80 deg C. Any higher temperature is produecd by albedo and direct solar radiation, which accounts for the P_a- and P_s-terms. The degree to which albedo and solar radiation influence the equilibrium temperature depends on the value of α/ϵ (*Fig. 2*).

As α/ϵ approaches zero, the shell temperature becomes increasingly independent of the orbit characteristics and hence of the sun-earth-satellite geometry. Since this geometry introduces the time dependence into the heat-balance equation, a small α/ϵ can be used to minimize the influence of time on satellite thermal control.

Ratio depends on optical properties

The value of α/ϵ depends on the optical properties of the satellite's outer surface coating. Camack and Edwards classify satellite coatings according to their optical properties as flat absorbers, ($\alpha/\epsilon = 1$); flat reflectors ($\alpha/\epsilon = 1$); solar absorbers ($\alpha/\epsilon > 1$); or solar reflectors ($\alpha/\epsilon < 1$). *Figure 3* shows the spectral characteristics of the emittance of these coatings.

As Drummeter and Schach point out, it is the absolute values of both α and ϵ that determine the magnitude of the temperature excursion of a surface coating subject to time-varying radiation.[4] The larger either of these values is, the more rapidly will the surface absorb radiation—and the more easily will it lose the resultant energy gain by reradiation. The mean temperature, however, will depend only on the α/ϵ.

A precise definition of either α or ϵ (since the two are considered equivalent in definition) is important. The total normal emittance (ϵ) of a solid surface is

(3) C. M. Schmidt, A. J. Hanawalt, "Skin Temperature of a Satellite;" *Jet Prop.* 27 1079 ('57).

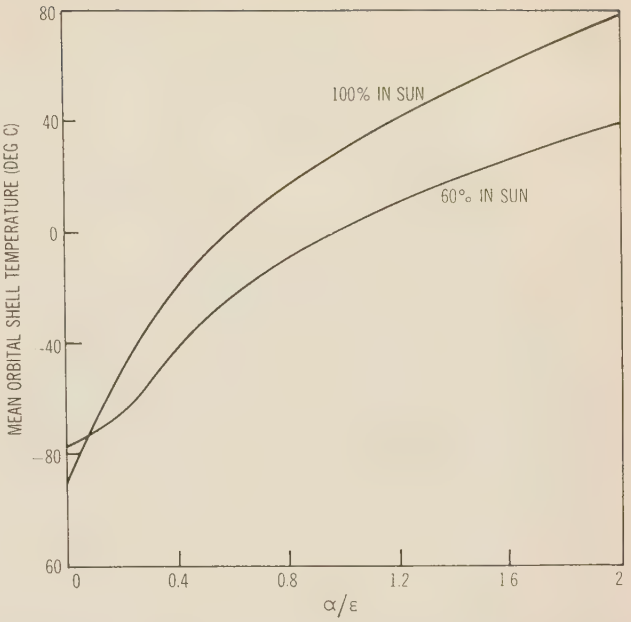


FIGURE 2: Effect of α/ϵ ratio on the mean orbital shell temperature of a spherical satellite for various periods of solar illumination.

defined as the ratio of the total thermal energy normally radiated by a unit area of the surface at temperature T (in degrees K) to the total thermal energy radiated by a unit area of a black body at the same temperature:

$$\epsilon = \int_0^\infty \epsilon\lambda E\lambda d\lambda \Big/ \int_0^\infty E\lambda d\lambda. \tag{6}$$

Besides being a function of wavelength, ϵ_λ is also a function of the angle at which the surface emits radiation. Emittances found from measurements of the energy captured in a hemisphere surrounding a unit area of the surface therefore differ some from the emittances found from measurements normal to the same surface. Butler and Inn show that the hemispherical emittance values of polished platinum are 30-100

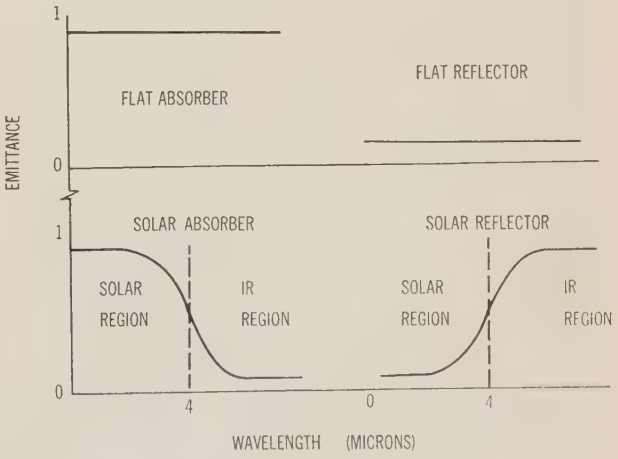


FIGURE 3: Classification of spacecraft surface materials on the basis of their optical properties.

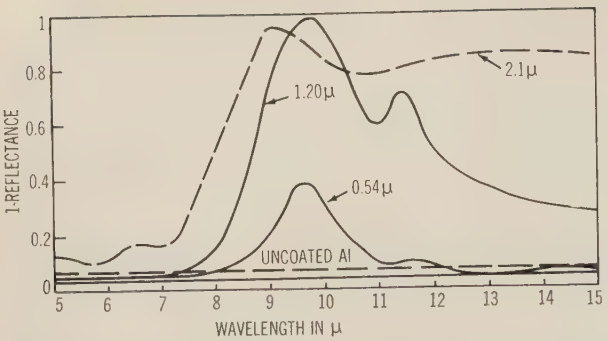


FIGURE 4: Emittance characteristics in the infrared region of electrolytically polished aluminum protected by Al_2O_3 (dashed curve) and of unpolished aluminum protected for various thicknesses of S:O.

per cent higher than the normal values.[4] They also show that the total hemispherical emittance is a function of the temperature of the sample itself and reaches a minimum (for polished copper) around 10 deg C. The prior thermal history of a sample also seems to affect the emittance.

For satellite coating, the flat reflectors (used, for instance, as thermal isolators between skin and interior package) and the solar reflectors are most important. Flat reflectors can be approximated by ordinary aluminum, which has low-emittance characteristics at both short and long wavelengths. Hass reports that the emittance characteristic can be lowered by using the metal in polished or electro-plated form.[5] As a vacuum-deposited coating, aluminum yields a surface of extremely low emittance whose excellence extends into the ultraviolet region of the wavelength spectrum.

Silver, fiberglass also used

Vacuum-deposited silver also approximates a flat reflector, but its low-emittance characteristic does not extend as far into the ultraviolet region as does that of aluminum. A dark-green fiberglass laminate also has been reported as an excellent flat reflector.[6]

Because of their excellent short-wave low-emittance characteristics, flat reflectors (especially vacuum-deposited aluminum) are used as substrates for solar reflectors. To get the high emittance in the infrared region, non-metallic materials are deposited on an aluminum substrate. These deposits absorb radiant energy at infrared wavelengths but are transparent to radiant energy of shorter wavelengths. Both Al_2O_3 and SiO have strong absorption bands at a wavelength of 10 microns, which corresponds to the maximum wavelength emitted by a black body operating at around 20 deg C. Since this is a very good temperature at which to operate a satellite, the absorption properties of Al_2O_3 and SiO are used, to adjust the emittance characteristics of satellites, acting as radiators at that temperature.

Figure 4 shows the infrared-region emittance characteristic of electrolytically polished aluminum protected by about 2.1 microns of Al_2O_3. As Hass explains, the emittance in the very-long-wavelength region can be reduced by decreasing the thickness of the Al_2O_3 film. A wave reflected from a surface has a node directly at the surface, and so there is only little energy available at that point for capture by the absorbing material. The availability for capture increases with the thickness of the absorbing layer and becomes appreciable once the layer thickness exceeds half a wave-length. In practice, the thickness of an Al_2O_3 coating can be precisely controlled by anodical treatment of the aluminum, and aluminum surfaces can be prepared to any emittance value between 0.03 and 0.8 (at 20 deg C).

The emittance property in the infrared region of aluminum coated with SiO can also be varied by controlling the SiO film thickness (*Fig. 4*). This can be done by adjusting the rate of SiO evaporation during vacuum-deposition.[7] The emittance can also be changed by oxidizing the SiO in the film to SiO_2, which has a higher infrared absorptance. The degree of SiO oxidation can be heightened either by heat-treating the coated surface in air or by lengthening the deposition time of the SiO in a less perfect vacuum to increase the chance of oxygen interaction.

Figure 4 shows that the high-emittance characteristic of Al_2O_3 extends to the longer wavelengths, while that of SiO decreases quickly at wavelengths of more than 11 microns. This difference is important for thermal control of satellites whose skin temperatures extend down to —80 deg C.

In actual practice, Explorer satellites were thermally controlled by modification of the structural materials themselves, which apparently had been chosen without regard to thermal control. The shell was made of steel, which was protected against aerodynamic heating by Rokide, an AlO ceramic. The steel used on the satellite's cylinder had an α/ϵ of 1.92, while the steel in the nose cone had an α/ϵ of 4.12. The α/ϵ-ratio for Rokide was 0.437. Since the satellite was spun, only the average value of α/ϵ over the surface was important. By covering 25 per cent of the area of the cylinder with Rokide stripes, an α/ϵ of 1.37 was obtained. A 30 per cent Rokide striping of the nose gave an α/ϵ of 1.61.

Explorer payload was insulated

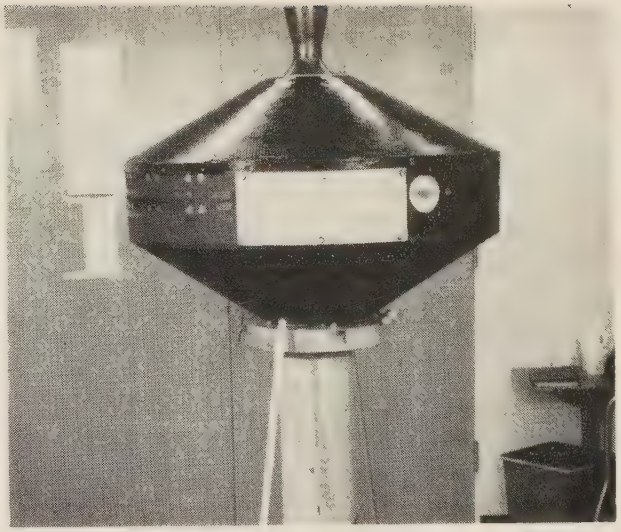
Tests of a prototype Explorer showed that the electronic payload could be so well insulated from the shell that its temperature varied by only a few degrees while the shell temperature varied by more than 100 deg C. The instrumentation was thermally isolated from the skin by micarta and fiberglass support structures as well as by component mounting in plastic foam. The Explorer's temperature range was predicted as 25-40 deg C, but the actual telemetered temperatures ranged from 19 to 55 deg C.

The Pioneer payload was covered by a shroud, so that it was not subjected to aerodynamic heating. The probe's nose cone was made of fiberglass, the outer surface of which was covered with a gold wash. Of this surface, 44 per cent was then striped with white paint. A part of the cylindrical main body was shielded with gold-plated aluminum foil, 40 per cent of which was painted black. Another portion was sprayed with aluminum paint.

Unlike the Vanguard and Explorer satellites, in which

(4) C. P. Butler, E. C. Y. Inn, "A Method for Measuring Total Hemispherical Emissivity of Metals" in "First Symposium—Surface Effects on Spacecraft Materials;" *op. cit.*
(5) G. Hass, "Filmed Surfaces for Reflecting Optics;" *J. Opt. Soc. Am.* 45/945 ('55).
(6) R. McDonough, "Emissivity of Materials near Room Temperature" in "First Symposium—Surface Effects on Spacecraft Materials;" *op. cit.*
(7) Hass, C. D. Salzberg, "Optical Properties of Silicon Monoxide in the Wavelength Region from 0.24 to 14.0 Microns;" *J. Opt. Soc. Am.* 44/181 ('54).

internal packages were insulated from the shell, the Pioneer probes depended on massive thermal inertia and good thermal conduction to the outside for interior thermal control. This approach was made necessary by the transmitter, which dissipated three watts, and the stringent requirement that the temperature remain within 20-50 deg C. The interior package was thermally connected through magnesium and aluminum supports to that portion of the exterior which was sprayed with aluminum paint. The Pioneer moon probe reached an equilibrium temperature of 42 deg C after nine hours, though the design equilibrium temperature was 35 deg C.



PIONEER probes required massive thermal inertia and good thermal conduction to the outside. The interior package was thermally connected to a portion of the exterior coated with aluminum paint.

The Tiros used a Rokide coating

The Tiros weather satellite had solar cells over most of its outer surfaces—they covered 77 per cent of the top area and 60 per cent of the side area. The remaining area was protected by Rokide. Bausch & Lomb was to develop an oxidized SiO film coating for the solar cells to increase their infrared emittance but did not have it ready in time; in its place, a thin glass plate was cemented to each cell together with a 15-layer interference film that rejected the blue portion of the solar spectrum. Apparently the adjustment of α/ϵ was critical for Tiros, for it was estimated that a change in the overall α/ϵ of the outer surface could cause a change of 10 deg C in the interior.

Direct thermal conduction was used for interior thermal control. The payload instrumentation was made an integral part of the base plate and a high-emittance coating was applied to all interior surfaces to provide good radiative coupling between the interior components and exterior surfaces.

The interior component temperature of the Tiros was predicted at 20 deg C. The actual measured temperature averaged out to 18 deg C.

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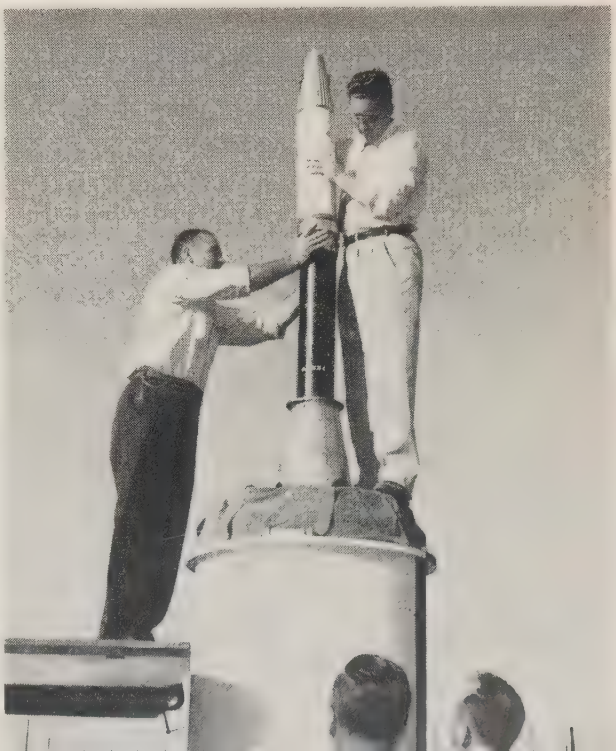
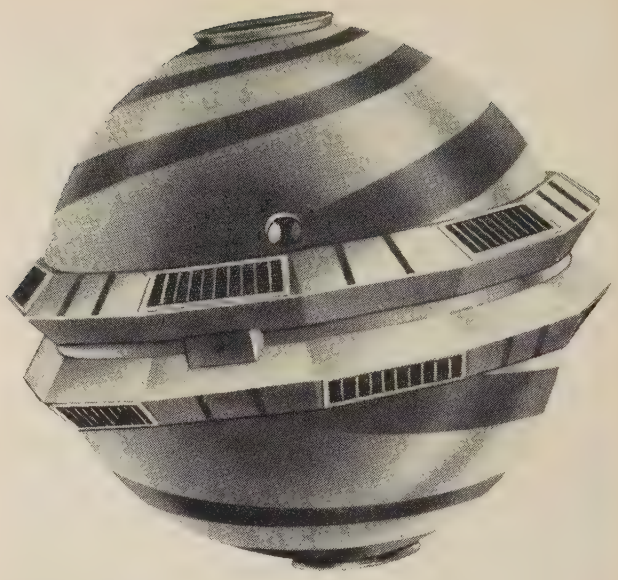
EXPLORER nose cone shows 30 per cent Rokide coating.



Spacecraft temperature control: breakthrough on Transit



CANDY-STRIPE organic coating on Transit I-B in artist's sketch. Coating pattern around solar cell arrays which helps prevent the overheating of the cells.

by Eileen B. Kress, Materials Information Branch, Materials Central, Airborne Systems Div., Air Force Systems Command*

WHEN SCIENTISTS at ASD's Materials Central were given the job of selecting the coating material for the Navy's Transit I-B navigation satellite, their goal was to find a coating that could be applied easily and cheaply and that could be varied easily for optimum temperature control. Organics met many of the application criteria, but at that time, it was generally held that they were disqualified by poor resistance to ultraviolet light and by a tendency to evaporate in space. The ASD researchers nonetheless decided to take another look at organics—and found that the evaporation theory was in error and that organic coatings actually are fully qualified for temperature control during extended space exposure.

In orbit, a satellite is exposed to several sources of heat: the sun, the earth's radiation and reflected solar energy, other celestial bodies, and waste energy generated in the satellite, such as electric resistance and mechanical friction. Of these, the sun is by far the most important heat source—it contributes about 90 per cent of the total heat. A satellite's temperature therefore varies from extreme heat during exposure to direct solar radiation to extreme cold during travel in the earth's shadow.

The sun is a source not only of thermal and ultraviolet radiation but also of energy. To take advantage of this energy, the Transit satellites and many others carry arrays of solar cells. Unfortunately, these solar cells won't function efficiently once they become overheated. If they are not cooled during exposure to the sun's radiation, extra cells must be carried along to make sure that enough power is generated. In terms of weight control, of course, extra cells are a very poor idea.

Metal coatings have drawbacks

Highly reflective metal coatings have been used for temperature control of satellites with great success. However, metal coatings by themselves are not enough, for they are limited in their ability to emit absorbed heat. For this reason, the first successful Vanguard

* Materials Central, Airborne Systems Div., Air Force Systems Command, Wright-Patterson AFB, Ohio.

Table I: Metallic vs Organic Spacecraft Coatings

	Solar Absorptance-Emittance Ratio	Equilibrium Temperature (deg F)*
Black organic	1.0	40
White organic	0.2	−125
Aluminum	4.0	250
Stainless steel	2.5	170
Aluminum plus clear lacquer	1.0	40
Aluminized silicone	1.3	60

*For a spherical vehicle in a 300-mile orbit.

satellite, for instance, used a coating of gold topped with a transparent layer of silicon monoxide. Other clear disadvantages of metallic coatings are that they often impair the properties of underlying metals and require immersion treatment or vacuum processing, which makes application a complicated business.

Difficulties in application become especially critical when a launch is delayed. Such a delay may involve a change in the parameters to which the spacecraft coating is designed and therefore require changes in the coating—which are much more difficult to make on metallic types than on organic ones.

For Transit I-B, all these considerations led ASD to devise a white organic coating. This satellite, designed by scientists of Johns Hopkins University's Applied Physics Lab, is made of plastic and weighs 265 lb. Launched in April 1960, it is a prototype for a series of four satellites scheduled to be in orbit by 1962.

The primary factors in choosing organic coatings for spacecraft are:

- the ability of the basic materials of both spacecraft and coating to reflect, absorb, and emit heat;
- resistance to ultraviolet light;
- the orbit of the spacecraft;
- the shape of the spacecraft.

Simply applied surface coatings offer a very attractive solution to the problem of spacecraft temperature control. This is particularly true for coatings that can be painted on, since their pattern can be quickly changed in case of delays in launching. Coatings made of organic materials fall into this "quick-change" category and in addition are relatively cheap and leave great leeway in formulation.

In the past, however, there seemed no doubt that organics could not stand up in space but would deteriorate under ultraviolet light and evaporate. As this article reports, scientists at ASD's Materials Central scored a major breakthrough in the course of developing coatings for the Transit I-B when they disproved this theory and discovered easily applied liquid organic coatings that, from all data telemetered back so far, stand up well under prolonged space exposure.

Coating was applied in stripes

As the sun is the prime source of heat, most of the heat absorption can be determined by the area of the spacecraft that is exposed to sunlight. The emittance, or reradiation, of the absorbed heat then determines the temperature of the craft. As *Table I* shows, the white coating applied to Transit I-B produces an equilibrium temperature of —125 deg F in a 300-mile orbit. Since the desired temperature was about 70 deg F, the coating was applied only in carefully selected areas to provide a specific balance between heat absorptance and emittance. It is this selective application of the coating that gives Transit I-B its candy-stripe pattern.

The polyurethane base Transit coating looks like and can be applied like paint. A chemical mixture of polyester resin and toluene diisocyanate catalyst pigmented with titanium dioxide, it has a very white appearance and absorbs heat very weakly but has high emittance.

In one month of orbiting, Transit I-B is exposed to ultraviolet radiation equivalent to that of over 30 years of southern Florida sunshine. This ultraviolet radiation posed the danger of yellowing, which would significantly decrease the coating's reflectance and therefore increase the heat absorption and the equilibrium temperature. The constant temperature radioed back from Transit I-B shows, however, that no yellowing has occurred. The polyurethane coating apparently is entirely stable.

Two other organic coatings have been formulated by ASD for the Journeyman space probe. In one of them, black pigment was carefully blended into a white enamel; for the other, aluminum flakes were added to a black enamel (*Table II*). The general goal of ASD's work on organic coatings is to obtain a high order of ultraviolet and thermal resistance in a vacuum and to synthesize additives to protect, or stabilize, this resistance. Both these requirements appear to point to the ferrocenes, a class of organo-metallic "sandwich" compounds with unusual thermal stability. ASD tests of such compounds, synthesized for the production of either resins or additives, show complete ultraviolet stability—something never before reported in the literature. Preliminary results indicate that these compounds may be suitable both as plastic materials and as improved ultraviolet absorbers.

Table II: ASD Organic Spacecraft Coatings

		Solar		Temperature (deg F)		
	Vehicle	Absorptance	Emittance	Sphere	Flat Plate	Striped Sphere
White	Transit	0.18	0.95	−135° F	−70	−20
Silver-gray	Journeyman	0.53	0.95	−30°	50	32
Black	Transit	0.97	0.95	45°	145	85
Black	Journeyman	0.95	0.80	65°	160	120

Which engine for the supersonic transport?

by **Andrew Sanne,** Associate Editor

STUDIES of supersonic transports show that fuel will account for roughly half the takeoff weight of such a plane and for a perhaps even larger proportion of the direct operating cost. The choice of an efficient supersonic powerplant therefore clearly will be of vital importance. This choice also will have to take into account the problems of sonic boom and of takeoff noise.

Many designers look on the non-afterburning turbojet as the logical powerplant for a supersonic transport. Its advantages include low SFC at high cruising speed, low weight, small frontal area, basic simplicity, and, of course, availability.

More recently, the turbofan has become a strong contender as it has proved its worth in subsonic commercial and military planes. It offers a considerable reduction in jet velocity, and therefore in noise level, at takeoff. The sonic-boom problem is reduced, too—as a duct-burning design, the turbofan provides more thrust for acceleration to supersonic speeds at high altitude. It also consumes less fuel at subsonic speeds than does a straight jet, and because of its higher air flow, offers the possibility of supersonic cruise at relatively moderate turbine-inlet temperatures.

More novel proposals for supersonic transport propulsion are the turbo-ramjet and the turbofan-ramjet. In both these designs, a gas turbine is pretty literally put in front of a ramjet, and in both the great advantage would be that the gas turbine could simply be shut down during supersonic cruise.

How these four engines compare in supersonic operation has been explored by Pratt & Whitney Aircraft Div., United Aircraft Corp., East Hartford, Conn., in an extensive study. In terms of overall efficiency, the non-afterburning turbojet looks best up to Mach 3, followed by the turbofan, which uses some duct heating at Mach 3. (A mixed-flow turbofan, in which both

Straight turbojets, turbofans, and various combinations of gas turbines and ramjets all are in the running for powering the super sonic transport. Because of the tremendous fuel requirements of such a transport, powerplant efficiency will be crucial. To a large extent, this efficiency will depend on:

- **acceleration thrust capabilities for quick climb to avoid sonic-boom problems;**
- **design pressure ratio;**
- **turbine inlet temperature, which affects the specific thrust.**

This article shows how the powerplants proposed for supersonic transports stack up in terms of these parameters.

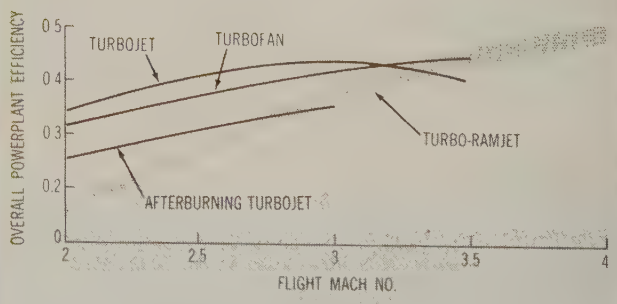


FIGURE 1: Powerplant efficiency at cruise, defined as (3600/HJ) (V/SFC), where H is lower heat of fuel (18,500 btu/lb for JP); J, Joule's constant; V, flight speed (in fps); and SFC, installed-thrust specific fuel consumption.

gas streams are augumented, is ruled out by its excessive cruise SFC.) The turbo-ramjet is competitive at Mach 3 and best above that speed (*Fig. 1*).

High acceleration thrust for quick climbing will be crucial for the supersonic transport (*Fig. 2*). This requirement is based largely on the need for high accelerations to avoid excessive sonic booms.

For all the engines studied by P&WA for which SFC varies with design pressure, a moderate ratio of 8 looks best (*Fig. 3*). An increase in specific thrust generally is possible with an increase in turbine inlet temperature. *Figure 4* shows how this temperature in turn affects specific weight and SFC.

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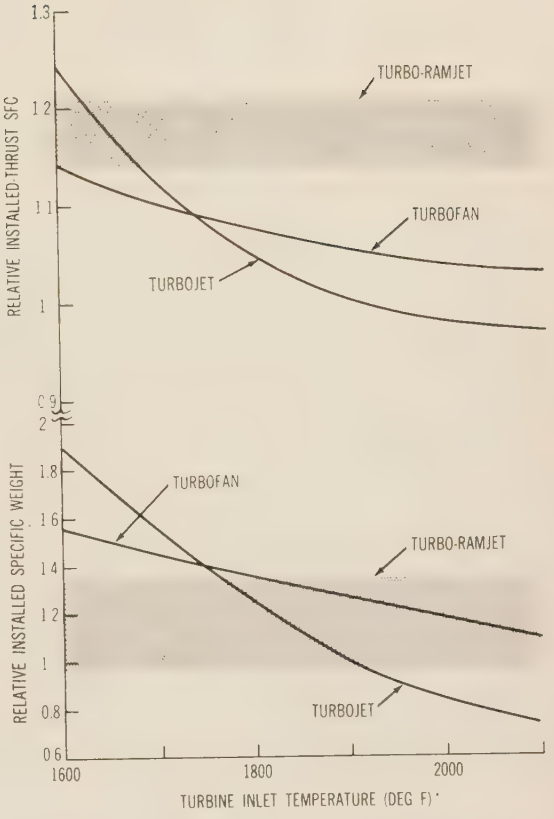


FIGURE 4: Mach 3 cruise parameters at minimum-thrust SFC and without blade or vane cooling (which would impose a weight penalty).

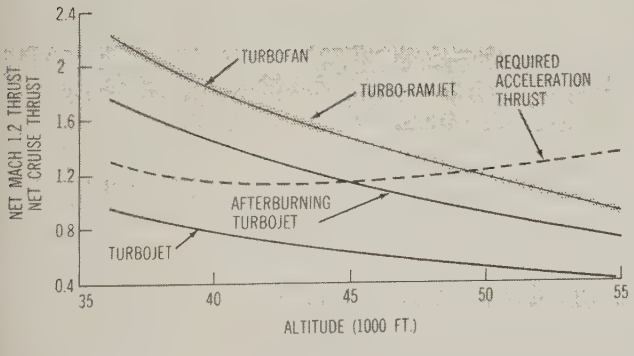


FIGURE 2: Acceleration-thrust characteristics, assuming cruise at Mach 3 and 65,000 ft.

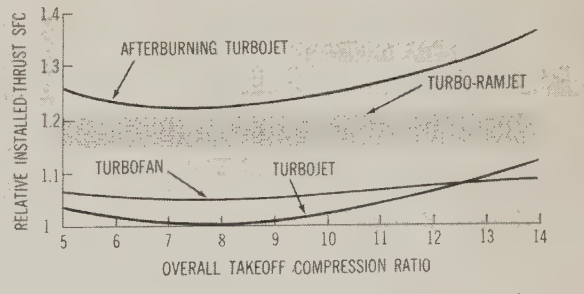


FIGURE 3: Cruise performance at Mach 3 and minimum-thrust specific fuel consumption. For all the designs studied by P&WA whose SFC varies with the design pressure ratio, a moderate ratio of 8 looks best.

Dynamic pressure on a moving body

THE PRESSURE acting on a body depends on the velocity of the body and the density of the fluid in which the body moves. If this fluid is air, various compressibility effects on the body alter the magnitude of the pressure loading, particularly on leading-edge surfaces.

The basic equation for dynamic pressure acting on a body in flight is:

$$P_s = \tfrac{1}{2}\rho V^2.$$

For an aerodynamic body and an air density of 0.0002 slugs/cu ft, this pressure loading is given by *Figure 1*.

However, a leading-edge surface is actually subjected to greater pressure. Because of thermodynamic compression, P is increased by the compressibility factor:**

$$F_c = \left[(1 + \frac{\gamma - 1}{2} M^2)^{\gamma/(\gamma-1)} - 1 \right] \frac{2}{\gamma M^2}.$$

This equation can be simplified to:

$$M < 1 — F_c = 1 + M^2/4 + M^4/40 + M^6/1600,$$
$$M \geq 1 — F_c = 1.839 - 0.772/M^2 + 0.16/M^4 + 0.035/M^6 + 0.0069/M^8.$$

Figure 2 shows these relationships in nomographic form.

A leading-edge surface in effect should be designed to:

$$P_s = \left(\tfrac{1}{2}\rho V^2\right) F_c = P F_c,$$

where P is found from *Figure 1* and F_c from *Figure 2*.

If the speed of an aerodynamic body is specified in terms of Mach number, you must find the value for V_s for the specified conditions from *Figure 3*. (Values of air density and temperature for various altitudes are given in standard reference books.)

* Westinghouse Electric Corp., Air Arm Div., Box 746, Baltimore 3, Md.

** W. F. Hilton, "High Speed Aerodynamics."

Nomenclature

F_c	compressibility factor
M	Mach number (V/V_s)
P	dynamic air pressure (psi)
P_s	stagnation, or leading-edge, pressure (psi)
T_h	air temperature at altitude (deg p)
V	velocity of vehicle (fps)
V_s	velocity of sound at temperature ($49\sqrt{T_h}$, fps)
γ	ratio of specific heats of air at constant pressure and at constant volume (1.40)
ρ	air density at altitude (slugs/cu ft)

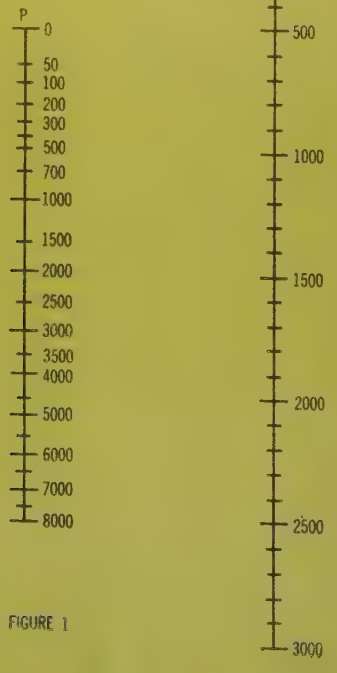


FIGURE 1

by Robert M. Sando, Fellow Engineer, Air Arm Div., Westinghouse Electric Corp.*

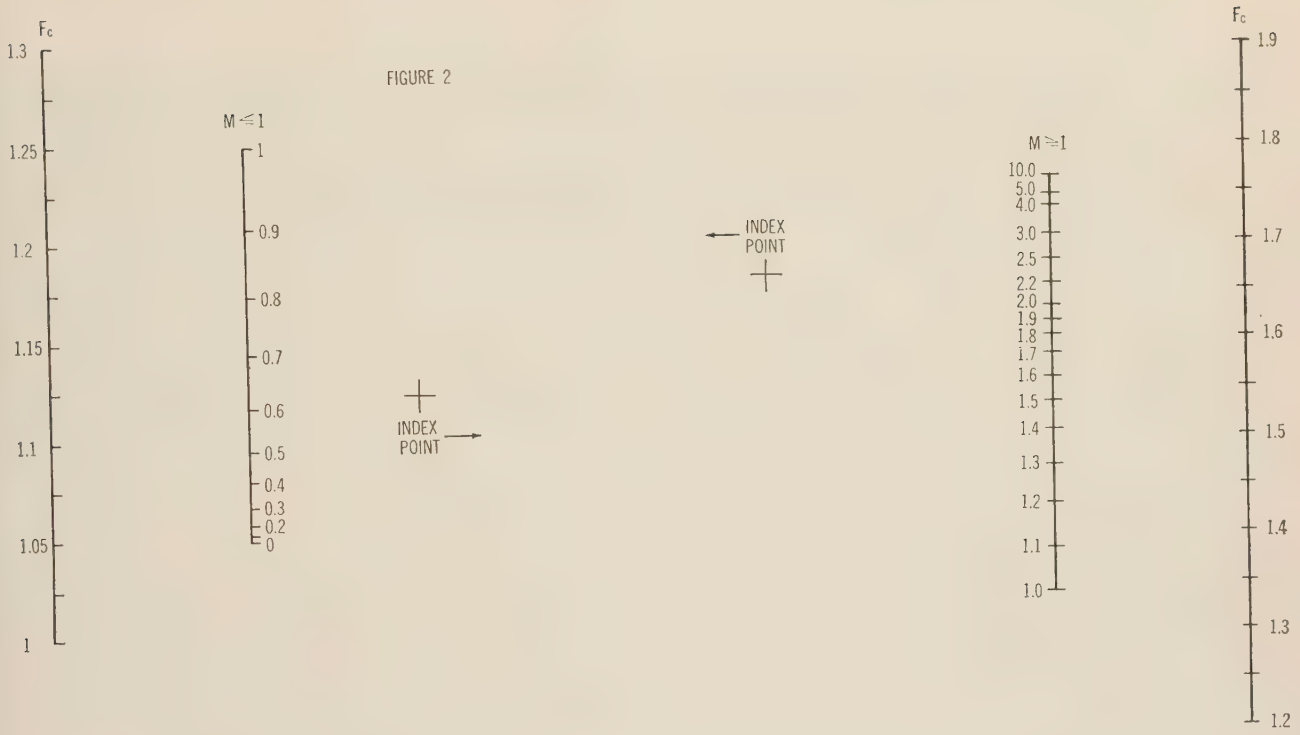


FIGURE 2

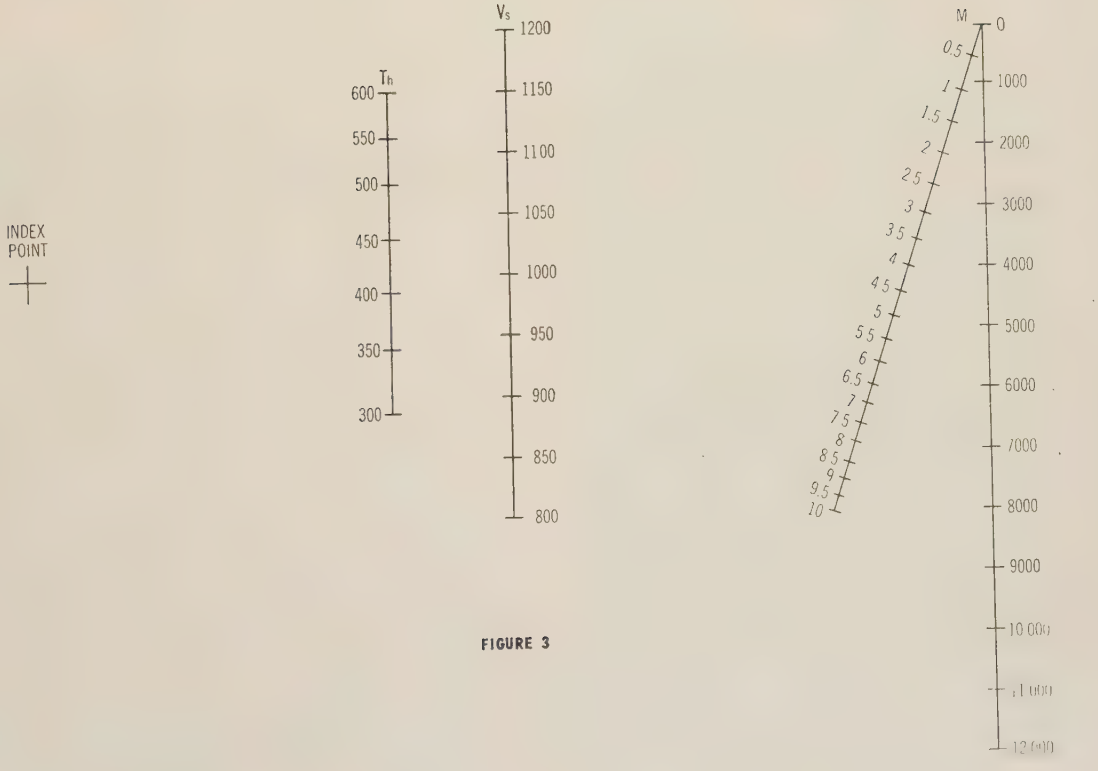


FIGURE 3

How to find the exhaust heat radiation of aluminized solid rockets

TO MEET the demand for high specific impulses, pulverized metal of high caloric value is often added to the basic combustibles of solid-propellant rockets. One of the most widely favored of these additives is aluminum, which has a melting point of 1219.5 deg F and a boiling point of 3733 deg F.

The aluminum particles in the propellant are coated with amorphous alumina. Subjected to heating, this alumina undergoes a series of changes until, at about 2102 deg F, it is transformed into α-alumina, which has a melting point of 3623 deg F and a boiling point of 6332 deg F. The pure aluminum exposed to the combustion process also forms α-alumina. A particle of α-alumina subjected to a rapid cooling retains its identity. Slow cooling, however, results in a phase change to ρ-alumina, an amorphous, metastable form of aluminum oxide that has no well-defined melting or boiling point and transforms into α-alumina if heated sufficiently.

* Aero-Space Div., Boeing Airplane Co., Box 3707, Seattle 24, Wash.

The launch temperature environment is a missile silo obviously is of prime importance for the silo design, and because of blast reflection it affects the missile structure, too. Since it depends virtually exclusively on the exhaust temperature of the missile powerplant, changes in this temperature as a result of the addition of metals to solid propellants become a major consideration for both silo and missile designers.

This article analyzes the effect of aluminum particles, a widely used additive, on the radiative heat of solid-propellant rocket exhausts. On the basis of an experimental study, the authors develop a general theory to explain the chemical changes undergone by the aluminum particles as a result of heating during combustion and show how these changes quantitatively and qualitatively depend on the rocket geometry and how they in turn affect the radiative exhaust heat.

What is more directly important is that the combustion of the aluminum produces microscopic particles that raise the effective emissivity of the exhaust plume, especially if the concentration of particles within the plume is high and the mean diameter of the particles is small (as it must be for optimum combustion of the particles). Combined with a high particle temperature, a high plume emissivity in turn produces an appreciable radiation flux, which becomes an important parameter for silo design. Boeing therefore made an experimental study to find:

- the radiation levels emitted by rocket engines as a function of geometric parameters;
- the physical and chemical properties of the particles in the exhaust plume of an aluminized composite-solid-propellant rocket.

First test results are plotted

Our first test results can conveniently be plotted as radiation flux vs the distance traveled by the combustion products (*Fig. 1*). The radiation flux from an exhaust plume with a low volume-area ratio decreased rapidly, while a plume with a high volume area ratio retained its radiating capability for a considerably longer time. As the radiation fluxes within the exhaust plume exceeded the values predicted for a gaseous radiator, they clearly had to be attributed to the presence of a dense cloud of particles. A study of the slag deposited downstream of the exit nozzles confirmed the presence of such a cloud of particles.

Microscopic examination showed, in fact, that there are two types of particles in the exhaust plume of an aluminized solid-propellant rocket:

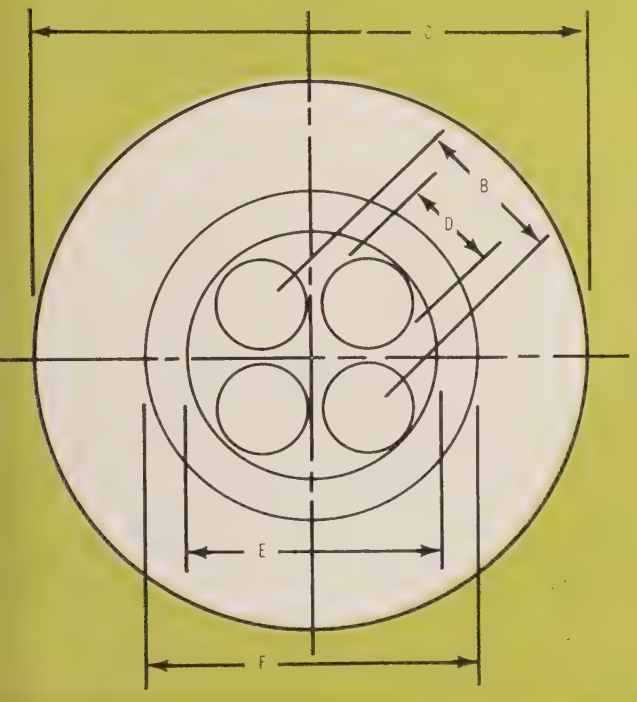
- spherical, hollow particles formed by the nearly complete diffusion of aluminum vapor from the interior of the particle through the porous alumina shell and comparable in size to the 5-50-micron aluminum particles originally added to the propellant grain;
- solid particles of an average size of less than one micron that does not depend on the size of the original aluminum particles.

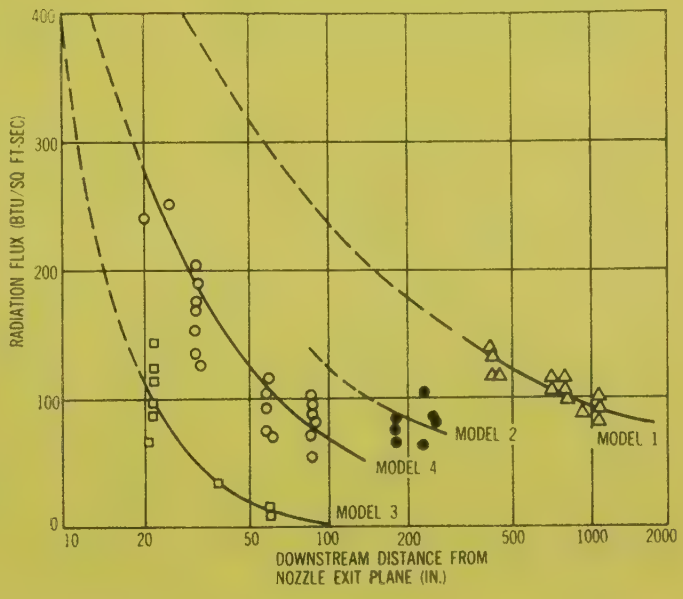
Figure 2 shows the particle size distribution in the exhaust plume. The size of the solid as well as of agglomerated particles increased with the distance from the nozzle exit plane. The particles collected near the

by D. D. Kurtovich and G. T. Pinson,
Research Engineer & Associate Engineer, Aero-Space Div., Boeing Airplane Co.*

	V/A	Dimensions (in.)				
		B	C	D	E	F
Model 1	19.7	41.0	144.0	24.5	65.5	74.0
Model 2	6.6	13.7	48.0	8.2	21.8	24.7
Model 3	1.0	2.05	7.2	1.23	3.28	3.7
Model 4	2.8		13.0		2.0	

FIGURE 1: Radiation fluxes for scale-models of aluminized solid-propellant rockets tested on a silo-like launch tube at a total chamber temperature of 6000 deg R and a total chamber pressure of 675 psia at sea level. V/A is the volume-area ratio of the exhaust plume.





exit nozzle were composed predominately of α-alumina; further downstream, there was an increasing proportion of ρ-alumina. The number of the fragile hollow particles drastically decreased with the distance from the engine chamber.

On the basis of our experimental evidence, we were able to formulate a general theory to explain the presence of the particles in the exhaust plume (see *Table*): As the original aluminum particles, which are random in size and shape and have an amorphous surface coating of aluminum oxide, are subjected to the heat released by the combustion of the other constituents of the propellant, the pure aluminum within the aluminum oxide coating melts. With further heat addition, this oxide coating is transformed into α-alumina. When the melting temperature of α-alumina is reached, the irregularly shaped aluminum particle assume a spherical shape as a result of surface tension. A further increase in temperature causes the pure aluminum to boil, increasing the pressure inside the particle. When the pressure differential across the shell of the particle exceeds the surface tension, the vaporous aluminum diffuses through the shell and combines with the oxygen from the propellant, forming molecular particles of α-alumina. These particles condense, agglomerate, and solidify as the temperature decreases again.

The hollow shells of α-alumina, which remain after the aluminum vapor escapes from the interior, solidify as cooling takes place outside the combustion chamber. Occasionally they burst, leaving irregular fragments in deposits. Both hollow and solid single particles agglomerate and form new, progressively larger particles.

The reason why the presence of many extremely small particles is so important for the thermal radiation of a rocket exhaust is that—unlike gases, which emit radiant energy only at a few wavelengths—such particles radiate as gray bodies, or throughout the entire wavelength spectrum. Our radiation measurements along the longitudinal axis of the exhaust plume showed conclusively that the radiation intensity decreased quite appreciably with the distance from the nozzle

Temperature Effects on Particle State

Temperature (deg F)	70	1300	3700	4500	4700
Aluminum interior	solid	molten	molten	boiling	vapor
Alumina shell	solid amorphous	solid α	molten α	molten α	molten α

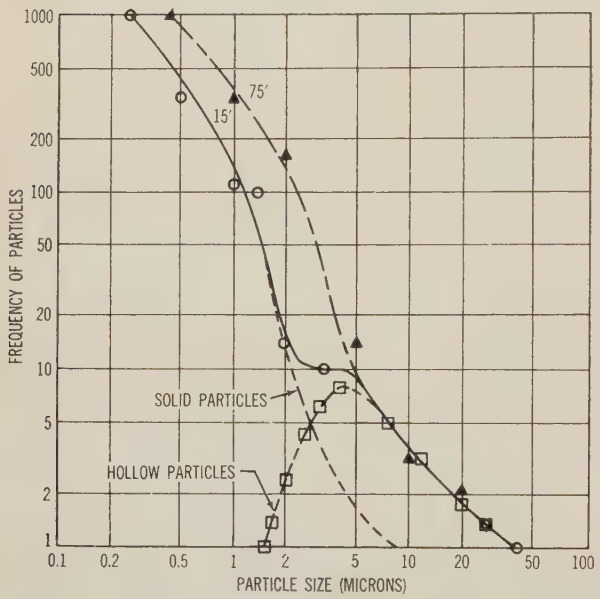


FIGURE 2: Particle size distribution at two distances from the nozzle exit plane at a volumetric particle concentration of 1.14×10^{-5}.

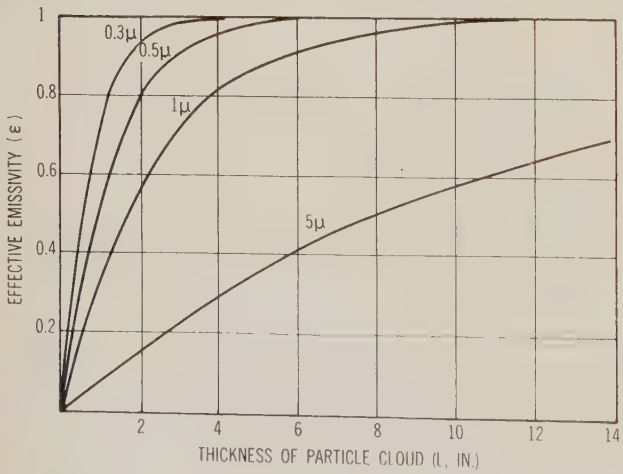


FIGURE 3: Effective emissivities of clouds containing particles of various sizes for an emissivity of 1 for each particle, a distance between particle in excess of the wavelength of incident radiation, diffused reflection, and a particle concentration of 1.14×10^{-5}.

exit plane. The drop in the total enthalpy of the combustion products caused by heat transfer from the plume to the surroundings accounted for only part of this decrease. About 80 per cent of the decrease had to be attributed to a rapid decrease in the temperature of the particles in the outer layers of the exhaust plume.

These particles form a potent radiator—either gray or black depending on its thickness and on the emissivity of the particles. The rate at which the radiant flux decreases represents a balance between the energy received from the interior of the plume and the energy emitted by the plume's external layers. As the thermal energy contained in the particles of the radiating layers accounts for only a small portion of the total enthalpy of the exhaust products, there can be a drastic reduction in radiation level with only a moderate loss in total heat content.

The intensity of radiation from a cloud of particles depends on the cloud's effective emissivity and temperature. If the chemical composition of the propellant, the combustion process, and the flow conditions are sufficiently well-defined, the concentration of solid constituents in the exhaust products can be determined chemically and thermodynamically.[1] Assuming a homogeneous distribution of particles within the exhaust plume, the effective emissivity can then be found as a function of the volumetric concentration, the particle

Effective emissivity is found

size, and the thickness of the gaseous layer. Hottel has shown that the effective emissivity of a cloud of particles can be calculated if the particles are opaque and have an absorptivity of 1, radiation is emitted and reflected in a diffused fashion, and the distance between particles is larger than the wavelength of the incident radiation (*Fig. 3*):[2]

$$\epsilon = 1 - e^{-NAL},$$

where N is the number of particles per unit volume; A, the average cross-section of a particle; and L, the length of the radiant beam through the cloud. For *solid* spheres with a uniform diameter (d), we can use:

$$N = \frac{C}{\pi d^3/\sigma}, \qquad A = \frac{\pi d^2}{4},$$

where C is the volumetric concentration of the spheres per unit volume of the gaseous products. This gives us:

$$NAL = (3/2)(CL/d).$$

If the particle concentration is high and the particle

(1) "Solid Propellant Handbook;" Boeing Doc. D7-2305, June '59.
(2) H. C. Hottel, "Radiant-Heat Transmission," in "Heat Transmission (McAdams, ed.); McGraw-Hill, '54.

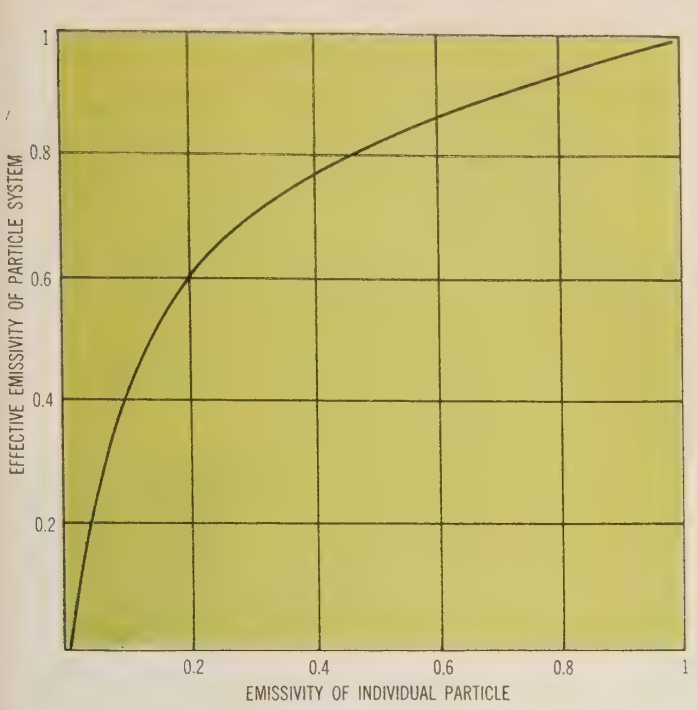


FIGURE 4: Effective emissivity of a particle system thicker than eight times the distance between particles. This curve is used to predict the emissivity of plumes whose particles have an absorptivity of less than 1.

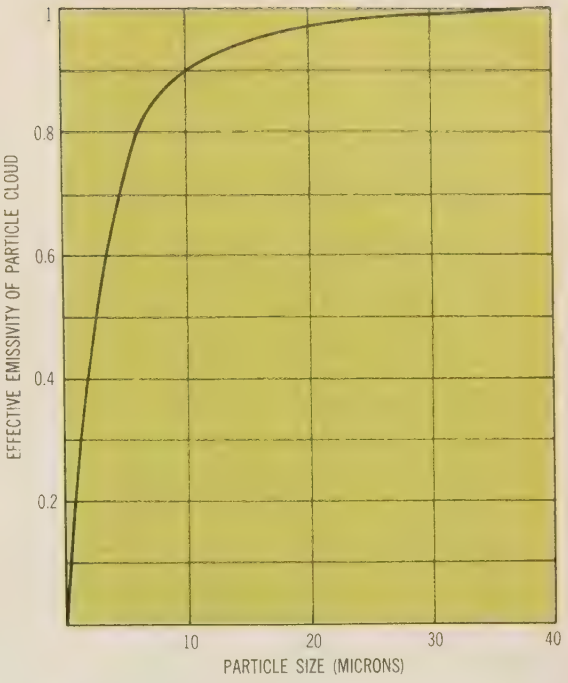


FIGURE 5: Effect of particle size on the emissivity of an exhaust plume for a one-foot-thick particle cloud and the particle distribution shown by the solid curve on Figure 2.

size very small, a cloud layer only a few inches in thickness produces a very high effective emissivity. By substituting *hollow* particles of the same external diameter for solid particles, we increase the number of particles for a given concentration and so raise the effective emissivity of the plume.

For a plume containing particles with an absorptivity of less than 1, the emissivity can be predicted by multiplying the values from *Figure 3* by the values shown in *Figure 4*.[3] The presence of particles comparable to, or smaller than, the wavelengths of the incident radiation causes a complex and poorly understood scatter and diffusion of the radiation beams. However, the effective emissivity of a plume characterized by a wide spread in particle size can be approximated by the summation of the emissivity values found on the basis of the concentration and the size of the particle system's individual components:

$$\epsilon = \sum_{n=1}^{n} \frac{C_n}{C} \left(1 - e^{-(3/8)(C_n/d_n)L}\right).$$

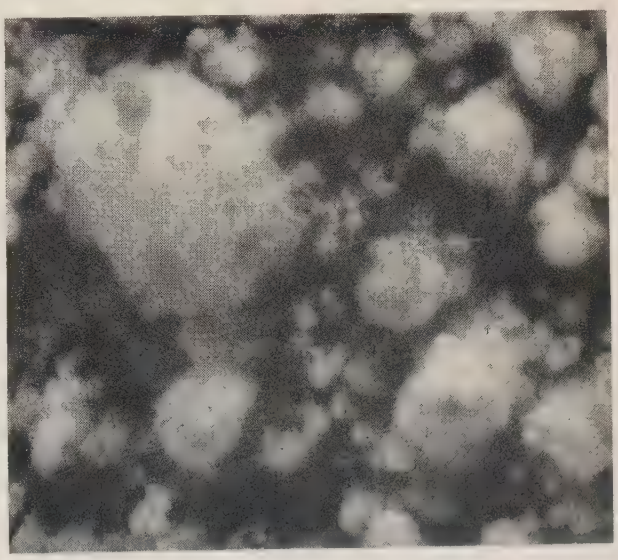
Figure 5 shows the overall emissivity of a cloud containing particles with the size distribution given in *Figure 2*. As we can see, the particles of less than five microns diameter account for most of the emissivity.

The thermal equilibrium that initially exists in an exhaust plume is distorted as soon as the plume's constituents are allowed to radiate to a relatively cold surrounding. As the effective emissivity of a cloud of particles is greater than the emissivity of the gaseous products of that cloud, the temperature of the particles tends to decrease faster than that of the gas. This is especially true for the particles on the periphery.

(3) J. R. Kriegel, "Radiation from a Gas Particle System;" STL, unpubl.

As the thermal equilibrium is upset, a heat transfer takes place within the cloud system itself by radiation from hotter to cooler particles and by convection from the gaseous constituents to the cooler particles. The greater the energy supplied from the interior (compared with the energy radiated from the external layers of the system), the longer will be the period of heat dissipation. Therefore, the radiation flux from a cloud of particles decreases with the distance from the exit nozzle at a rate inversely proportional to the volume-area ratio of the cloud.

SINGLE and agglomerated hollow alumina particles from an exhaust plume magnified 32.5 times.



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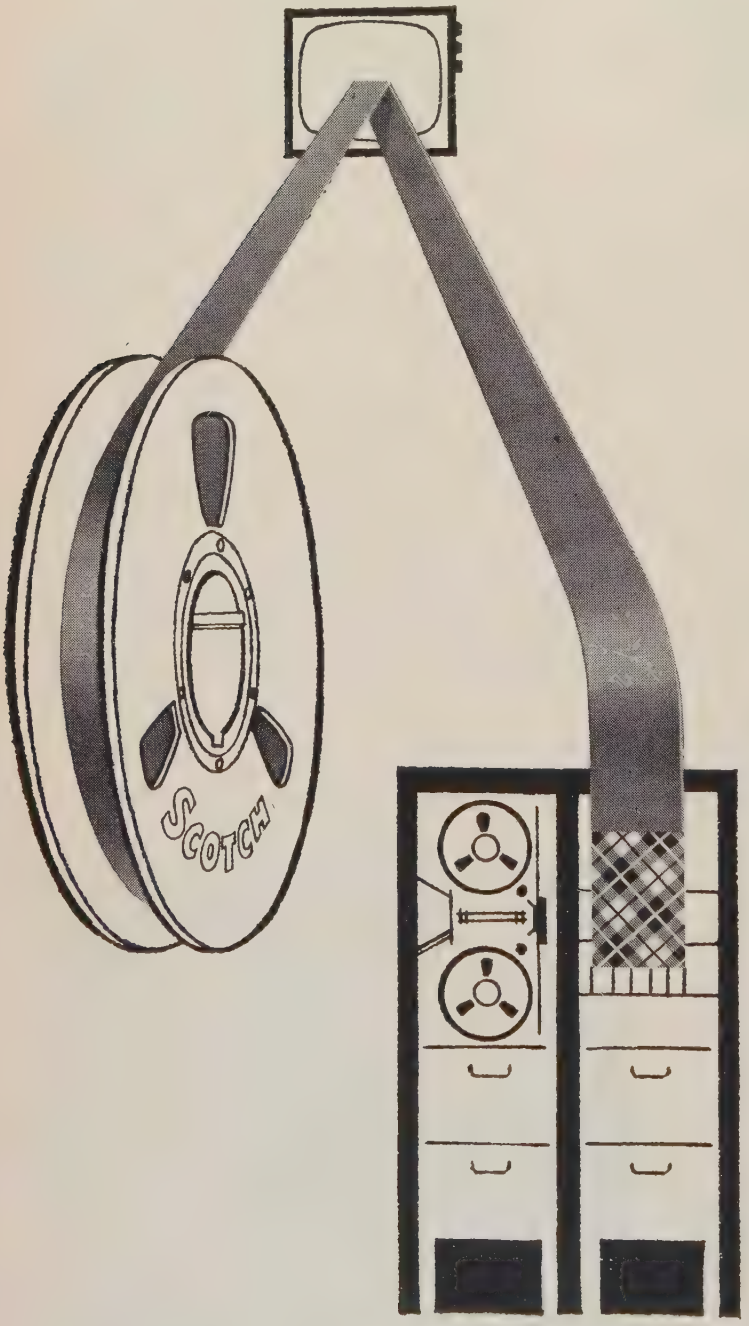

THE TIE that binds television's top performer to instrumentation tape is strong—and it goes beyond the fact that the same expert team produces the best of both. "SCOTCH" BRAND Heavy Duty Tapes share a common heritage—and uncommon endurance—with "SCOTCH" BRAND Video Tape, the tape that puts a network TV show on the same "clock time" from Maine to California.

Similarities worth noting between the two: a similar high-temperature binder system, famous "SCOTCH" BRAND high potency oxides, a similar ability to resist tremendous speeds, pressures and temperatures while providing high resolution.

Let's look at the record of "SCOTCH" BRAND Video Tape and see what message it has for the user of instrumentation tape. On a standard reel of video tape like that shown here, some 1½ million pulses per second must be packed to the square inch—on a total surface area equal to the size of a tennis court. The tape must provide this kind of resolution while defeating the deteriorating effects of high speeds, pressure as high as 10,000 psi and temperatures up to 250°F.

The fact is that video tape must be essentially perfect. And it's a matter of record that thus far only the 3M experts have mastered the art of making commercial quantities of video tape that consistently meet the demands of the application.

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The moral emerges: for tape that provides the best resolution of high and low frequencies under the severest conditions, turn to "SCOTCH" BRAND Heavy Duty Tapes 498 and 499.

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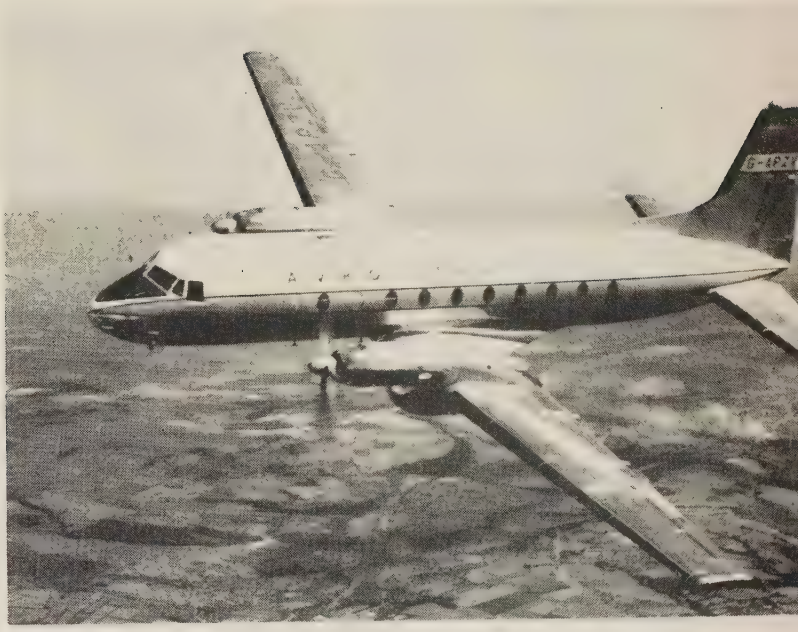
Avro 748 has novel fail-safe features

by **Christopher Dawson,**
Associate Editor



FIRST prototype of Avro 748. Twenty-four of the Dart-powered transports are on order.

THE AVRO 748 represents an all-out effort by A. V. Roe & Co. Ltd., to cater to the small civil operator. As a result, the emphasis is on reliability, easy maintenance, and low cost.

The choice of two Rolls-Royce Dart turboprops suggested the size of about 35,000 lb gross weight, at which 40 passengers will be carried over stages of up to 825 nm at 252 knots cruise. Many elements of the plane, including the engines, were taken over fully developed from the Vickers Viscount or Vanguard. Most of the original design features stem from the exceptionally thorough application of fail-safe principles.

To insure a long fatigue life, Avro took unusual pains to avoid cutouts and stress concentrations by applying its "principle of continuity."

In the most striking application of this principle, not only is the wing center section carried through the fuselage in the usual way, but at the same time the fuselage structure continues uninterrupted through the wing—the two structures are interlaced without cutouts in either (*Fig. 1*).

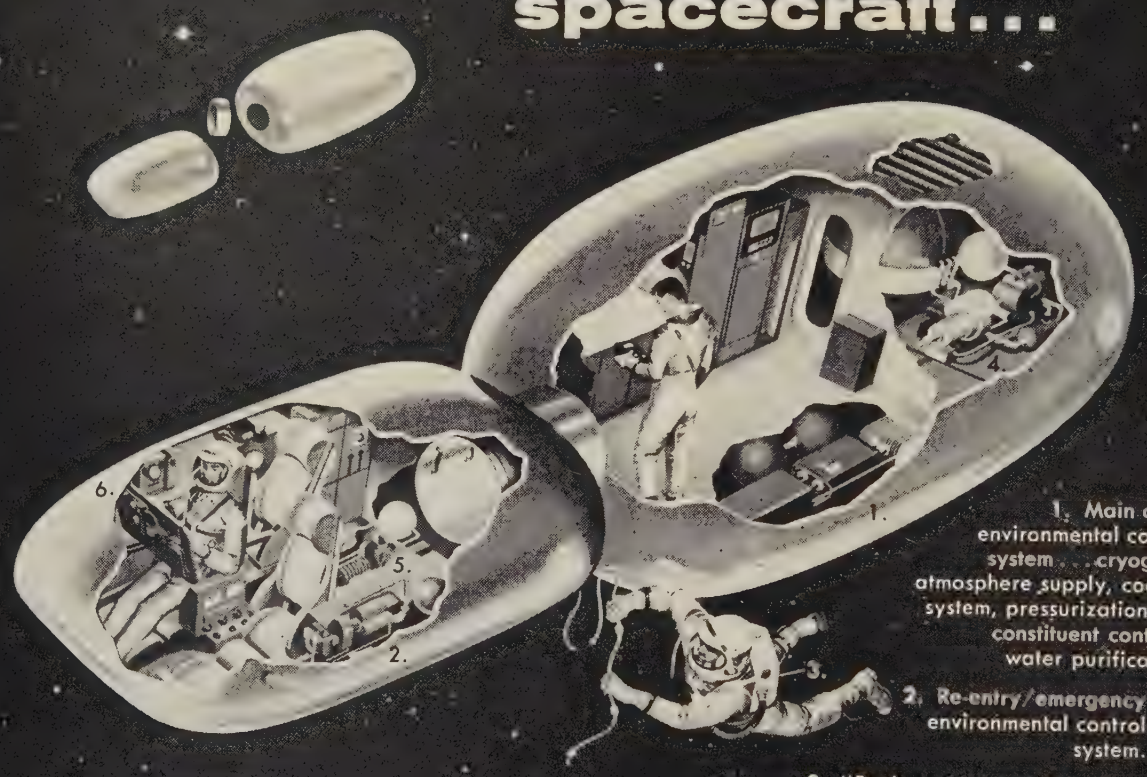
The upper surface of the wing forms the fuselage pressure boundary and has additional spanwise stiffeners on its upper face within the fuselage. The wing

Two conflicting requirements had to be reconciled by Avro in the design of its 748 medium-range turboprop transport: fail-safe design, which led to some complicated structural arrangements, and easy maintenance for which the structure had to be made highly accessible.

The fail-safe features of the 748 stem mainly from Avro's "principle of continuity." The wing center section and the fuselage, for instance, are both continuous.

To provide fail-safety in the accessory system, extensive duplication is used. A novel "ring main" system makes sure that the flaps can move neither asymmetrically nor on their own.

Environmental and secondary power systems for multiman spacecraft...


1. Main cabin environmental control system . . . cryogenic atmosphere supply, cooling system, pressurization and constituent controls, water purification.
2. Re-entry/emergency environmental control system.
3. "Back pack" breathing and pressurization system.
4. Secondary power system . . . multiple re-entry turbine, pump, alternator and cryogenic fuel supplies.
5. Attitude control system . . . reaction motor, fuel and attitude controls.
6. Instrumentation . . . flight data and physiological monitoring systems.

Manned space flight requires reliable and efficient thermal and atmospheric systems and secondary power equipment.

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centre section and fuselage are built in a single fixture as one unit. For inspection in this rather complicated part of the structure, there is a manhole in the front wing spar web giving access to the space within both wing and fuselage. The space within the wing but outside the fuselage is reached by swinging aside one of the wing rib ties.

Arvo also decided to avoid any break in the wing torsion box. To allow for retraction of the main landing gear legs, it therefore—in view of the legs' length and their location requirements in relation to the aircraft CG—had to provide special means for bringing the wheels far enough forward to clear the front wing spar. Each leg of the gear swings about a point forward of its axis (*Fig. 2*). The main load is thus carried through the downlock. The landing gear doors are linked mechanically to the legs so as to avoid the need for hydraulic sequencing.

In attaching the fin to the rear fuselage, the fin box is stepped into the fuselage like a ship's mast instead of meeting root attachment fittings that have to diffuse the loads into the frames and skin. The fin structure continues into the fuselage far enough to give a good lever arm and reduce the attachment loads (*Fig. 3*).

The two spars are each attached to a ring frame. The lower end of the rear spar is bolted onto a beam spanning the fuselage a little above mid-depth, while the front spar has its lower end attached to the rear pressure bulkhead by swinging links that allow deflection under pressure loads.

The fuselage formers are also continuous and have no cutouts, being formed from channel and fitted inside the stringers. Light angle pieces tie them to the skin. This arrangement also provides a crack-stopper between skin and frame.

Copper-bearing alloy equivalent to 24 S is used exclusively. Avro's aim is a minimum life of 30,000 hours. The design stresses are:

- wing—10,000 psi for a one-g load;
- fuselage hoop stress—9200 psi at 4.2 psi pressurization.

The Series 2 models will have cabins pressurized to 5.5 psi, which will bring the design hoop stress to a little less than 12,000 psi.

Avro has provided a multiplicity of load paths in all primary structures. The criterion has been that, with one member failed, 80 per cent of the ultimate design load should be sustained. Thus if the limit load is 1,

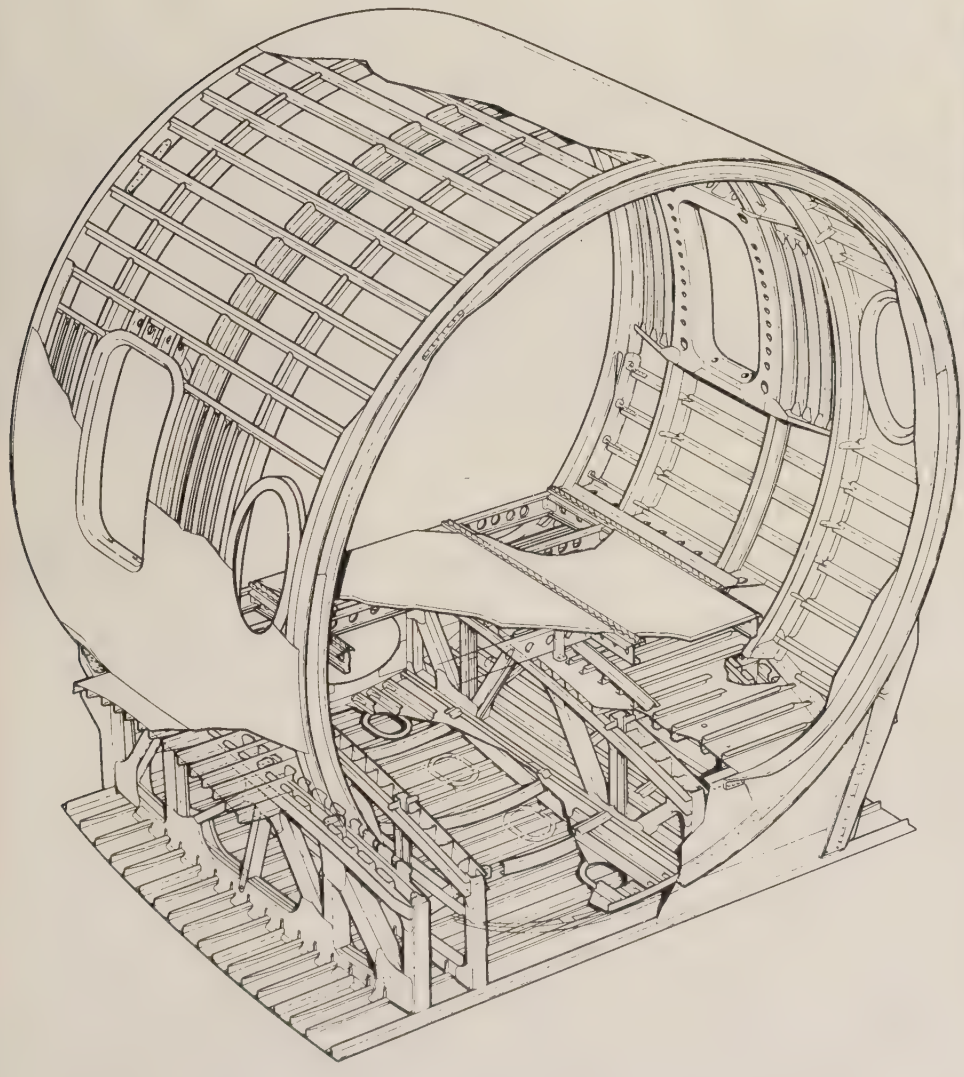
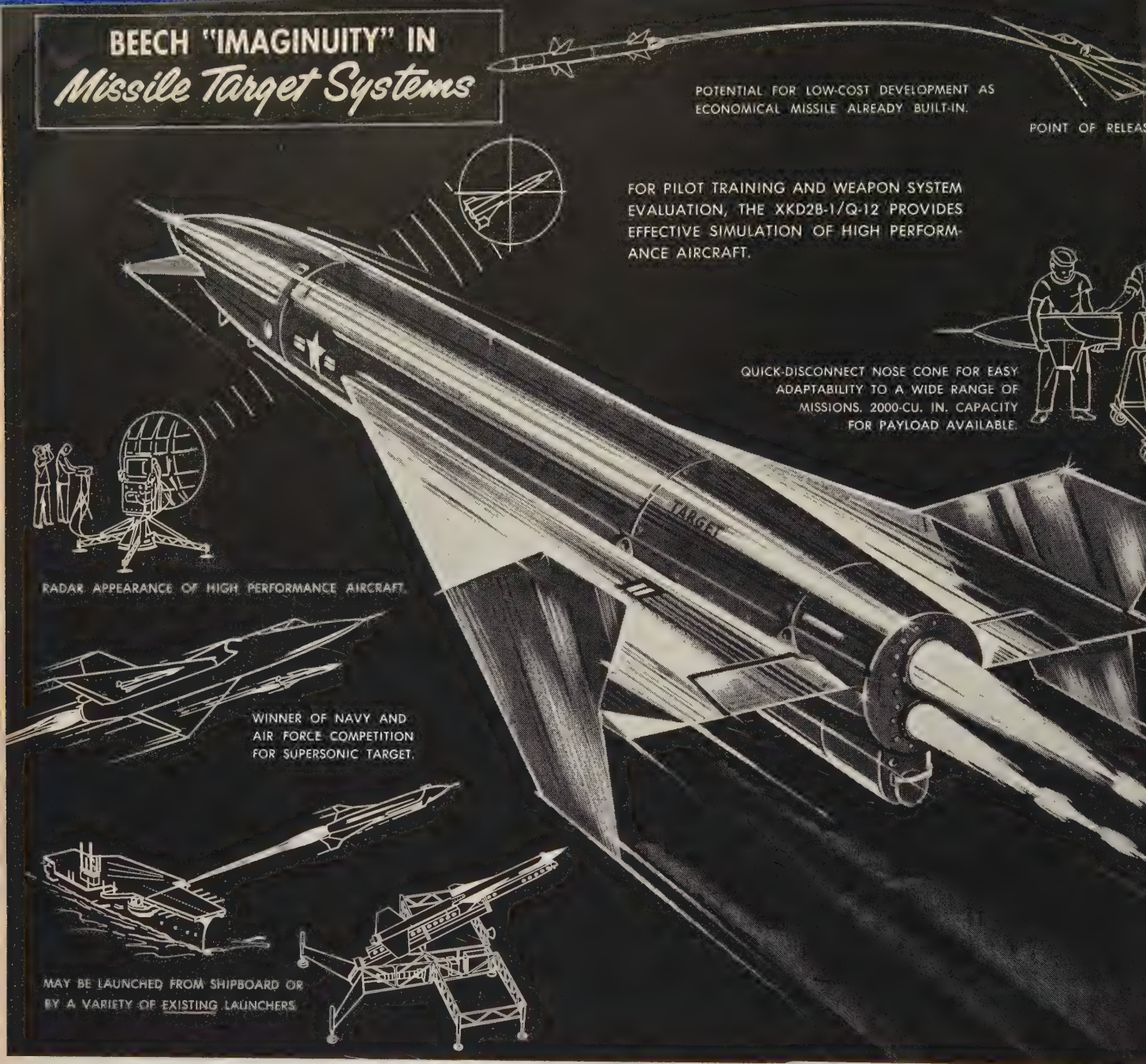


FIGURE 1: Wing and fuselage center sections are interwoven in accordance with the "principle of continuity" (left). Z-section stiffeners are added to help the upper wing surface carry the fuselage pressure loads. Right: Center rib bracing swings to one side for easy inspection of the wing root despite the complex structural arrangement required by the continuous fuselage.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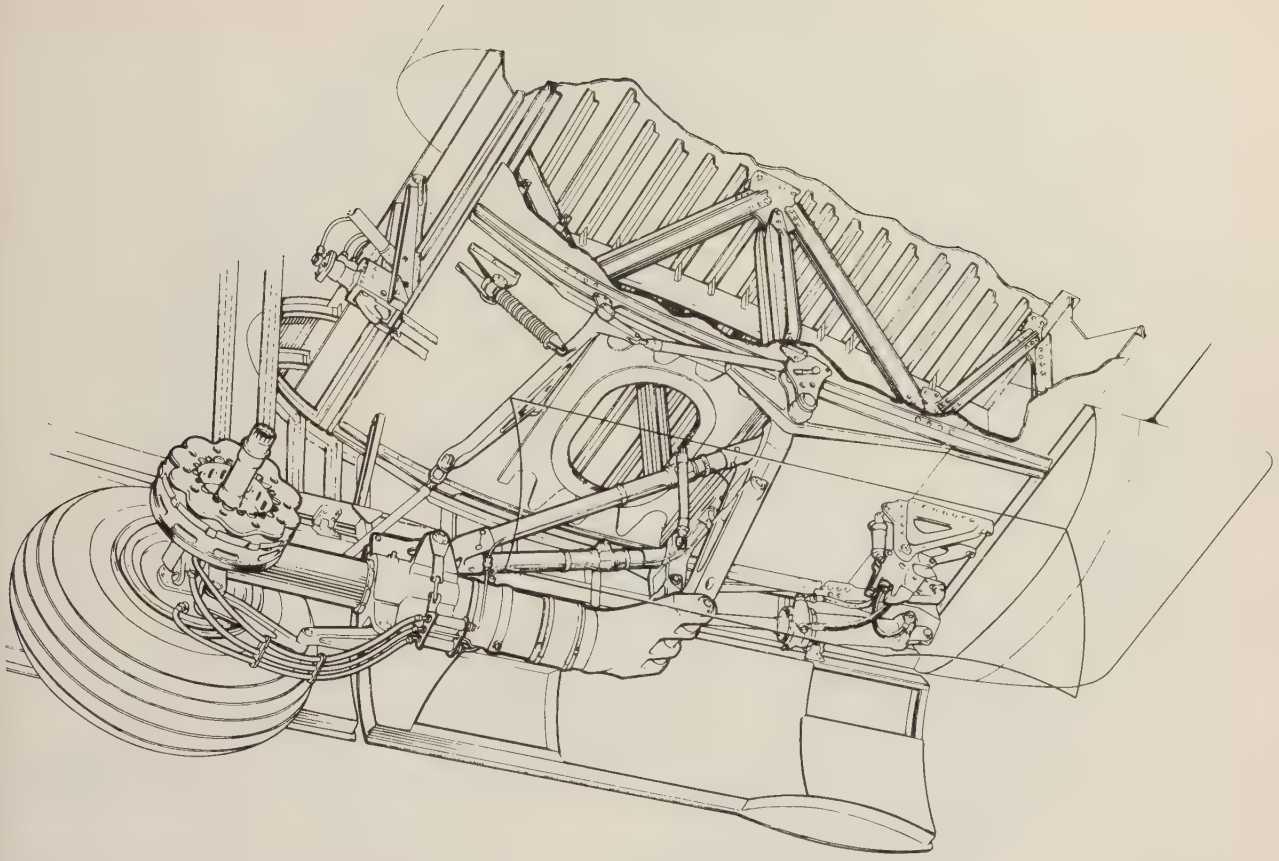


FIGURE 2: Partly retracted main landing gear leg. The down-lock, supported by the rear spar, transmits the main landing loads. Mechanical links connect to the landing gear door.

ultimate design load is 1.5, and the fail-safe load is 80 per cent of 1.5, or 1.2.

The aircraft's wing root stringer joint straps are duplicated. The wing skin panels are laid in strips to limit crack propagation. Ribs in all fixed surfaces are cross-braced and maintain their contour if one brace fails. The special ribs that support the engine mountings and the landing gear have bracing struts made up of four angles riveted together. The aileron hinge ribs make use of the shroud supports to provide a second load path. The other control surface hinge ribs of the 748 are similarly designed, and the same idea is applied to the flap tracks.

At the fin and tailplane attachment points, the loads are taken in shear, and the bolts pass through forged pad fittings. Each pad has a tongue, or groove, and the mating pairs have the tongue on one pad inserted in the groove of the other, but with a small clearance. If the bolt or fitting fails, the tongue and groove can take the load.

Many access panels are provided

In addition to the manhole giving access to the wing centre section there are six other manholes in the lower surface of each wing and four in the fuselage belly as well as a number of smaller access panels. Much structural testing and development went into the design of these cutouts and their reinforcement, so as to minimize stress concentrations. Structurally it would have been preferable to have the manholes in the upper wing surfaces, but they are much more difficult to use in that position.

Easy repairs were the main reason for going to a structure made up mostly of sheet and simple extrusions. To make sure the operator can carry out the more likely repairs in the field, welding and bonding were avoided. Honeycomb core sandwich is used only for the cabin floor, and the material for these panels is supplied in slabs that the operator can cut with a saw and leave without edge members. Even in the engine mounting frame, no welding is used.

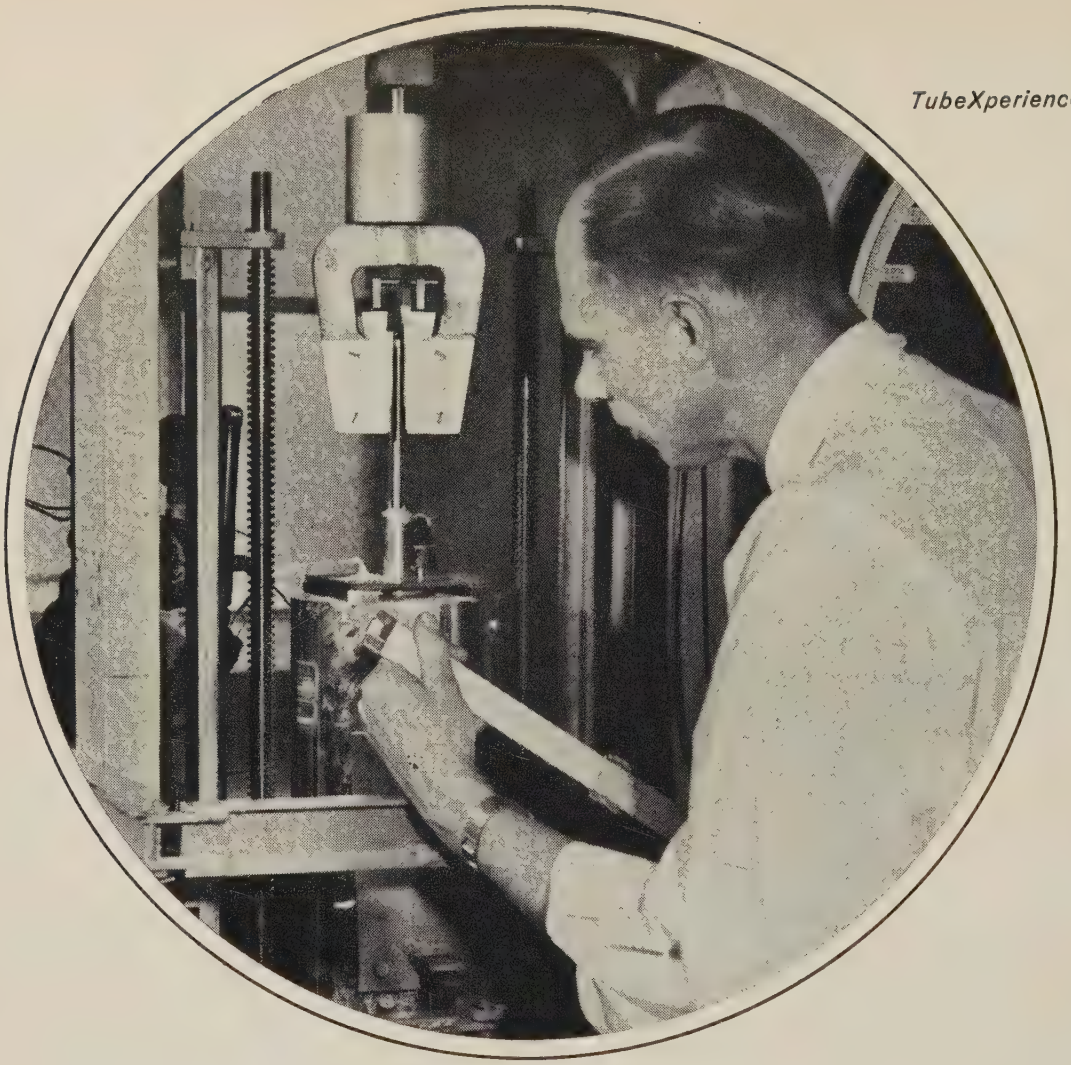
Craft has few breakable joints

The number of structural joints that can be readily broken is also small. This saves weight and reduces the number of sites for stress concentrations. The fuselage is built in one section, and the wing root joint is regarded as permanent.

Fail-safe design is used in the 748's accessory systems, too. The control runs are in cable, and if one cable fails, the aircraft can be flown on the trim controls. Each tab is operated by a jack with a large reserve factor through duplicated rods. Control hinge bolts are sleeved to forestall failure and are retained if the nut is missing.

Only the landing gear and the brakes are hydraulically operated. In the event of hydraulic failure, the landing gear can drop by gravity and be raised by a hand pump. The AC and DC electric systems are duplicated.

TubeXperience in Action



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Inconel 702[2] • Hastelloy X[3] • Hastelloy C[3]
Haynes 25[3] • Waspalloy

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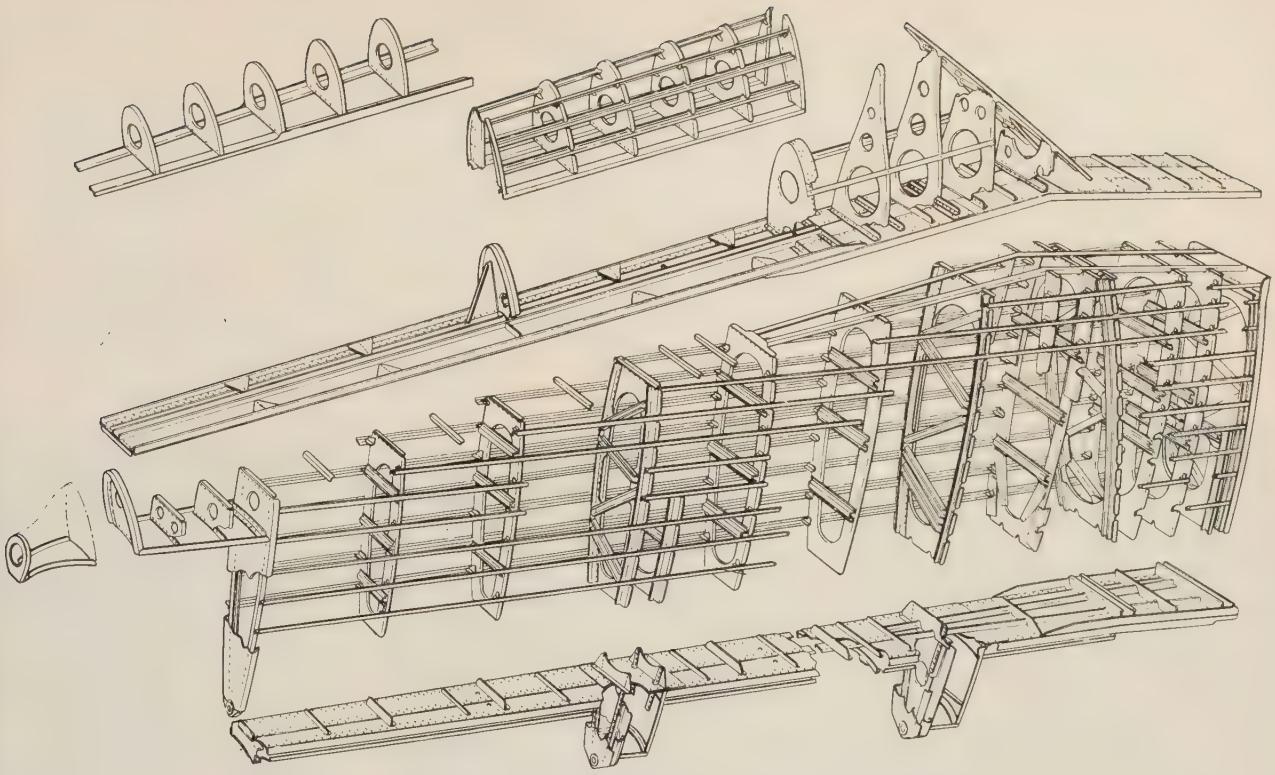

FIGURE 3: Fin torsion box structure. The part below the inclined rib is buried in the fuselage.

"Ring mains" are used to operate the flaps. These are modified Fowler flaps mounted on carriages whose rollers run in tracks extending from the rear spar. They are extended and retracted by cables wound on scrolled pulleys. Each of the four tracks on each side has its own pulley and cable system.

ARB (the British equivalent of the FAA) requires that flaps should never move asymetrically. Avro has added a requirement of its own: The flaps should never move by themselves. The scrolled cable pulleys are rotated by torque shafting that is driven electrically through an irreversible worm gear. The drive includes a slipping clutch that keeps the flaps from being lowered at too high a speed. The "ring main" consists of a second torque shaft running parallel with the main one and coupled to it by chain drives at two points on each wing (*Fig. 4*). The whole system is so worked out that if any coupling or shaft fails there is still a closed path to drive at least three of the four scrolled pulleys in each wing.

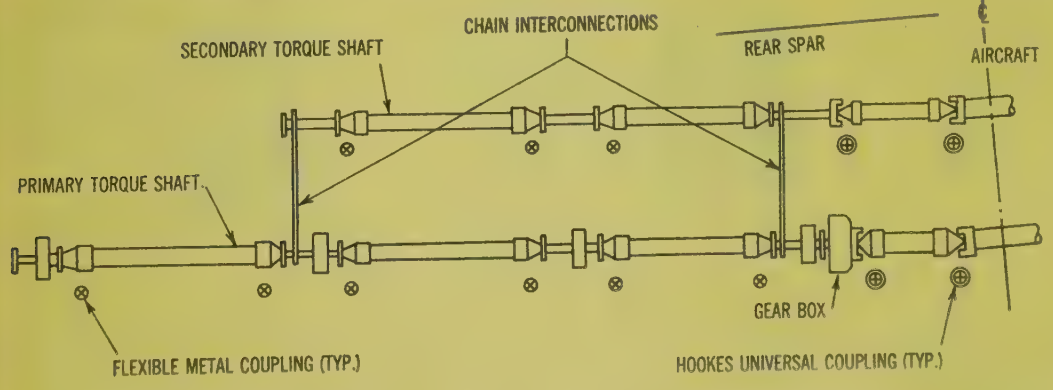

FIGURE 4: "Ring main" system for the flap torque shaft. Although there is only one gear box (on the port side), no single failure in the circuit can cause loss of flap position control.

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EXPLORER SERIES Over 20 General Precision components have assisted in the launching of these satellites.

MIDAS General Precision has developed and is now producing control moment gyros to stabilize MIDAS satellite with reference to earth when satellite is in orbit.

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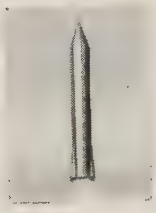

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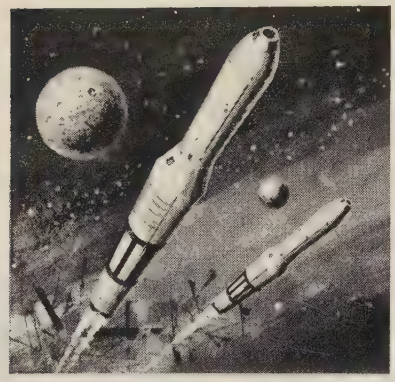
Performance Demonstrates Efficiency and Economy of Armco 17-4 PH Stainless Steel



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Performance of thousands of aircraft and missile parts made of 17-4 PH proves the efficiency and reliability of this special Armco Stainless Steel. Its combination of 200,000 psi strength, high hardness, ability to withstand heat and its excellent corrosion resistance permits weight-saving designs.

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Armco Division, Armco Steel Corporation, 3211 Curtis Street, Middletown, Ohio.

ARMCO

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No. 30 on Reader Service Card

Orbital simulator

tests satellite reliability

by **W. G. Camack and C. A. Ellis,** Missiles & Space Div., Lockheed Aircraft Corp.*

For effective reliability testing of spacecraft and their systems, the environment in which they will function must be closely approximated. Lockheed's Hivos simulator is one of a growing number of facilities designed for such environmental testing. It reproduces, as nearly as possible, the two most important conditions of the space environment—low pressure and extreme heat and cold—and maintains them for long periods.

The Hivos test chamber can be used for satellites as large as the Agena. Its vacuum system can reach and maintain a pressure of 10^{-8} mm Hg or even less. Thermal flux on the test vehicle can be varied from 1000 down to one btu/hr-sq ft. An automatic programing and data system lets all the components in the satellite operate as they would in orbit.

LOCKHEED'S Hivos (*h*igh-vacuum *o*rbital *s*imulator) grew out of the need for testing complete satellites in simulated space thermal and vacuum environments to provide much of the data needed to improve system reliability and performance. Complete space environment simulation including such factors as chemical composition, ionization and excitation, and kinetic energy, would of course be even better, but it would also be very expensive. As a practical proposition it probably isn't even feasibile, and we certainly did not attempt to achieve it with the Hivos design.

The Hivos facility consists of test chambers, vacuum system and instrumentation, bake-out system, thermal simulator, thermal sinks, and thermal simulation control (*Fig. 1*). The test chamber is a 20-ft-high tank with an ID of 18 ft. It is raised 47 ft above the main floor of the building.

The port in the bottom of the chamber is sealed with a blank head for the bakeout conditioning of the chamber and with another to support the test vehicle, the thermal simulator, and the lower thermal sink. This head has about 2000 feed-throughs for control and instrumentation wiring.

The heads are sealed in place by double O-rings in dovetailed grooves. The rings are protected by a guard vacuum so that sealing is by gasket displacement rather than distortion.

Baking prepares chamber for test

In preparation for a test, the interior of the test chamber is conditioned by baking at 500 deg F. This temperature is held until the top and bottom heads, the thermal sink, and the 36-in. baffles have achieved stable and clean surfaces. After baking, the chamber pressure is brought to ambient with dry, gaseous nitrogen. The bake-out system also cleans liquid nitrogen baffles contaminated by diffusion-pump oil and chamber walls and thermal-sink surfaces contaminated by vehicle outgassing.

The bake-out system consists of a Dowtherm fluid and piping system with the necessary heaters, dry and evaporative coolers, and controls. It can be programed to a predetermined cycle. During bake-out, the Dowtherm fluid circulates through immersion heaters. During cooling, the heaters are off and the fluid passes through the coolers. The chamber can be raised to 500 deg F within 4 hours and cooled back down to 100 deg F in the same time.

The Hivos vacuum design consists of a roughing and a high-vacuum system. The roughing system uses four rotary mechanical pumps which can reduce the test chamber pressure to 10^{-2} mm Hg within 30 minutes from an ambient of 70 per cent relative humidity and 80 deg F. The pumps are manifolded from a common eight-inch line into a 16-in. main roughing line.

The high-vacuum pumping system uses 22 four-stage oil diffusion pumps with 22 36-in. nitrogen baffles and elbows arranged symmetrically around the chamber. These pumps have visual fluid-level indication and provision for manual addition of fluid during operation and quick shutdown with quench-cooling coils.

Each pump discharges into a 40-in. main fore-pressure manifold maintained by four diffusion-ejector

* Missiles & Space Div., Lockheed Aircraft Corp., Sunnyvale, Calif.

Minuteman Transporter-Erector. Prime Contractor—Boeing Airplane Company, Seattle Wash. Missile Container—Military Div. of Cessna Aircraft Co., Wichita, Kansas. Tractor & Trailer—GMC Truck & Coach Div., Pontiac, Mich.

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This huge transporter-erector will carry a Minuteman missile to its launching site, then raise it vertically, ready for placement in the underground launching silo. Magnesium was selected for many critical parts because of its stiffness and light weight . . . about 2250 pounds of sheet, plate and extrusions. This is 400 pounds *less* than the weight of the material originally considered.

The container must be light to meet highway load limits and rigid to protect the missile. For these reasons, all side panels, rear doors and access doors are made from magnesium AZ31B alloy sheet.

In the tractor unit, magnesium sheet and extrusions form the framework, panels, roof and floor. *Even the bumper* is of strong, lightweight magnesium alloy. Wherever a combination of light weight and stiffness is needed . . . for vehicle bodies, containers, housings, aircraft and missile structures . . . there's a Dow magnesium alloy to do the job. For information, write THE DOW METAL PRODUCTS COMPANY, Midland, Michigan, Merchandising Dept. 1113EW7.

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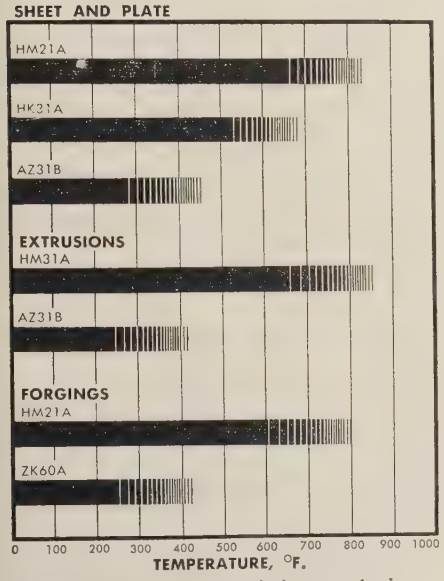

How thorium has extended magnesium's useful service temperature range.

High service temperature range and light weight . . . designers of missiles and aircraft can count on both with Dow magnesium-thorium alloys for elevated temperature use. This family of alloys offers strength and resistance to creep at high temperatures. Magnesium-thorium alloys are used in the Polaris, Titan, Talos and Bomarc missiles; in Agena and Scout vehicles; and in the F-105 aircraft.

Forgings of Dow alloy HM21A have excellent mechanical properties up to 800°F. Other alloys for extrusions, and sheet and plate, are available for use in the 300°— 800°F. range, for body skins, ducts, cowlings, electronic equipment housings, wings, fins and other applications.

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ORBITAL SIMULATOR

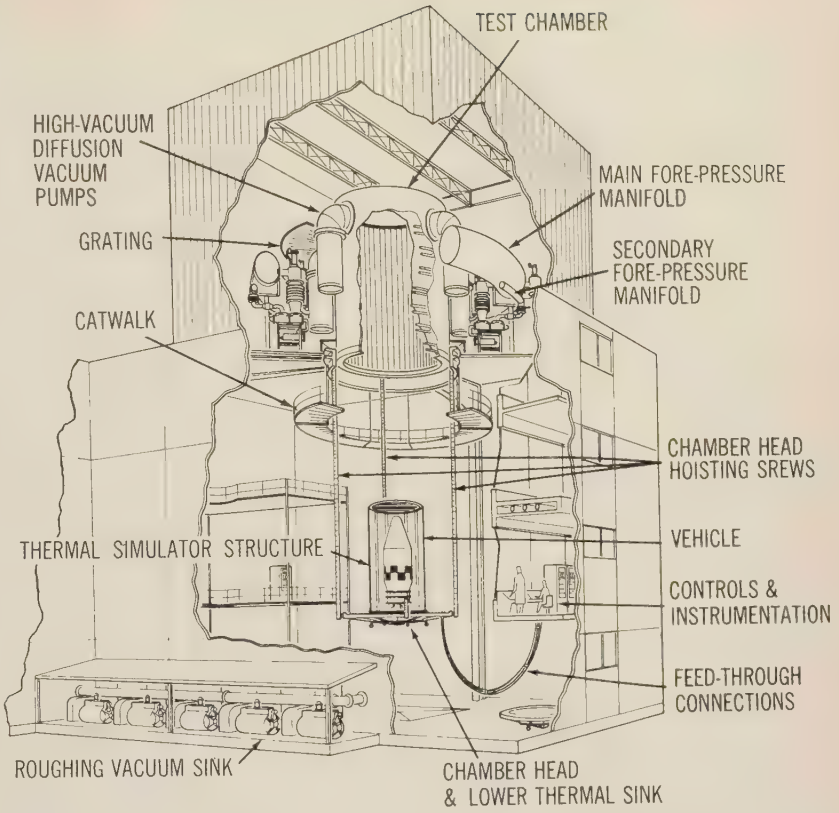

FIGURE 1: Ball and screw jacks raise the Hivos chamber head into position with an Agena satellite mounted on it. The head can support 10,000 lb.

pumps. Each pump, valve, and baffle can be operated separately from a main control console. Any pump in the vacuum system can be removed for servicing or replacement without impairing system operation.

The complete vacuum system provides empty-chamber pump-down from 760 to 10^{-8} mm Hg in four hours. Chamber operation during pump-down is automatic. The instrumentation system measures and records temperatures and pressures in both the high-vacuum chamber and pumping system. Four gage stations within the chamber's thermal sink include exposed Bavard-Alpert, Pirani, Philips, and thermocouple gages. Two mass spectrometer heads, located next to the gage stations, analyze constituent gases with molecular weights from 2 to 150. Another spectrometer head is located in a 36-in. elbow.

Failure of any system component does not interrupt system operation. During power failure, an auxiliary generator energizes critical valves and pumps.

A central control board visually indicates the operation of all system elements. To insure test continuity in case of a failure in auxiliary equipment, all system elements, including emergency interlocks, can be manually actuated.

Except during their passage through the atmosphere, most spacecraft travel in such rarefied atmospheres that the only significant external mode of heat transfer is radiation. Within the vehicle itself, heat transfer takes place by radiation, conduction, and (in pressurized vehicles) by forced convection. To set up thermal conditions that will cause the components and structural elements of a test vehicle to operate at the same temperatures as under environmental conditions, external energy sources must be simulated. For the Agena satellites tested in the Hivos facility, these sources are the sun and the earth.

In the Hivos chamber, the radiant energy sources are provided by the thermal-radiation simulator, made up of banks of quartz lamps with reflectors. There are twin rows of quartz lamps arranged vertically in a reflector system that forms a skeleton cylinder about 17 ft long and 9½ ft in ID (*Fig. 2*).

This world-wide communication network will help Strategic Air Force leaders exercise command and control almost in response to events of the moment. Yet the forces involved are dispersed throughout the world, the volume and complexity of information unprecedented. ¶ The SAC Control System will be a product of the new technology of automated information processing assistance. We have helped create this new technology, beginning with our work on SAGE. In projects such as SAACS and SAGE, we perform system analysis, information processing system design, and training of personnel in system use. And as a continuing effort, we carry on research into future generations of these control systems.

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The globe shown is the Dymaxion projection by R. Buckminster Fuller. It depicts the spherical world as a flat surface with a minimum of distortion.

For control purposes, the lamp and reflector assemblies are divided into 26 zones. As they are set up in two rows, the lamps can be operated at half rated voltage or less, which makes for greater reliability and longer life.

Twelve vertical, evenly spaced zones of lamp and reflector assemblies take up the top seven feet of the cylindrical section, and another twelve take up the bottom ten feet. One zone each is located across the top and the bottom, normal to the cylinder axis.

Polished aluminum creates modified Fresnel effect

Each lamp and reflector assembly has a large rear and a small front reflector. The rear reflector is a heavy aluminum extrusion with an integral cooling tube on the rear. Polished aluminum surfaces give a modified Fresnel mirror effect, approximating a modified catenary.

The front reflectors are aluminum half-cylinders. A slit along the element towards the vehicle provides uniform flux. For a cylinder five feet in diameter, the maximum flux deviation at the edge of each zone is three per cent.

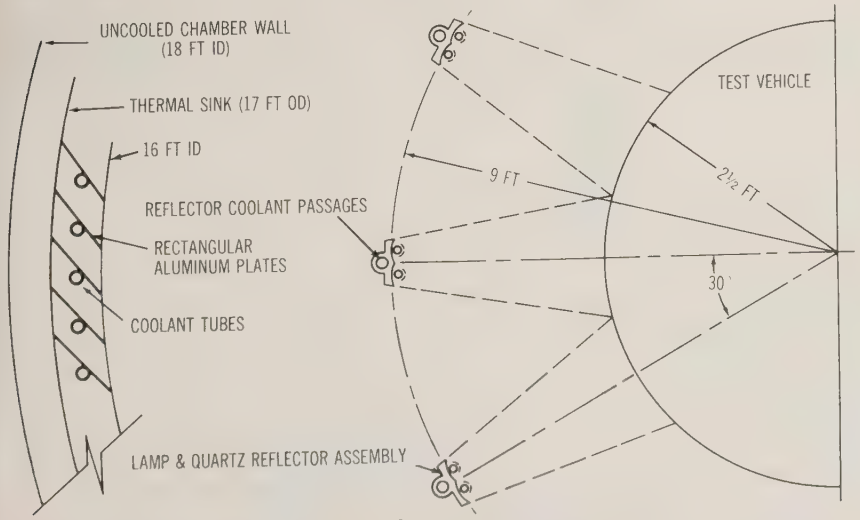
The cooling tubes on the reflectors carry methylene chloride at a temperature between -40 and 110 deg F to reduce radiation and improve system response. The cooling response is expected to be better than 20 minutes for the drop from 1000 to 10 btu/hr-sq ft.

Cooled thermal sinks are installed on the chamber wall and the instrumented bottom head. They are held at —320 deg F to reduce the flux striking the vehicle to about one btu/hr-sq ft. Compared with other factors in the satellite heat balance, this is low enough to be negligible and is a good approximation of actual space.

The clear ID from sink wall to sink wall is 16 ft. Vertical plates around the chamber wall in a turbine-wheel arrangement give adequate pumping conductance. The vertical section has three zones, each with its own separate rate liquid-nitrogen supply system. The plates surrounding the chamber wall are made of extruded aluminum and 16 ft long and one foot wide. The cross-section of each plate is a rectangle with a coolant tube on the back through which the nitrogen flows. The top and bottom heads have extruded chevrons supported in the same manner as the vertical plates.

All surfaces are sand-blasted, chemically etched, and treated wth a black, anodic finish. This treatment yields a total normal reflectance on each plate of 20 per cent for high-temperature lamp energy and 15 per cent for longer-wavelength radiation. For these two forms of radiation, the geometry of the thermal sink produces effective reflectances for the overall assembly of 10 and 13 per cent, respectively. In addition to the

FIGURE 2: The reflector-coolant passages of the Hives thermal simulator are used as structural members to support electric connectors heaters, lamp sockets, and coolant heaters. Lateral ring supports at top and bottom complete the structure.



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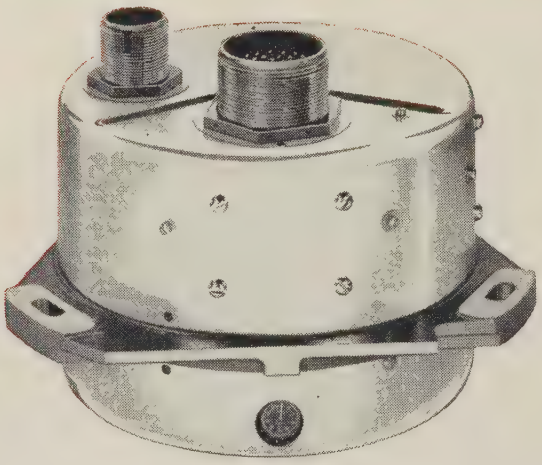

SELF-CHECKING RATE-GYRO PACKAGE

Here's further evidence of Giannini Controls' leadership in the support of inertial systems engineering. **Delivery to Titan of the project's first self-checking 3-axis rate gyros — backed up by Giannini-developed ground support equipment.** These prelaunch self-checking features include Operating Time Indication · Rate Simulation · Rotor Speed and Runup Time · Damping Ratio.

Giannini Controls' rate gyro capability includes long experience in meeting various requirements for excitation, pickoff, damping, rate range. Ask the people on Titan, F8U, Skybolt, Discoverer, Mercury, about rate gyros. You'll hear: **when it's from Giannini Controls you get it on time, it works when you get it, and it keeps on working.** Send for full data on Giannini Controls' Range of Rate Gyros and other inertial products.

COMPLETE GIANNINI TEST CONTROL STATION
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MODEL 36128 RATE GYRO
AC or DC power, floated, 1000-hr. rotor life, 2 x10^6 cycle pot life.

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GCC 1-25

fraction of a btu/hr-sq ft contributed by emission, the cold wall is estimated to add less than 7 per cent to the incident flux. With proper allowances, this addition causes only a negligible error.

The incident flux density in the chamber can be varied from 1000 btu/hr-sq ft to one btu/hr-sq ft by an analog programer in the flux control system. The programing of the thermal simulator is based on the fact that the flux absorbed in the chamber must equal that absorbed in orbit. The equation for the incident flux density in the chamber is:

$$I'_{er} = (a_s/a_i)\,[(K_1 + K_2\cos\theta + K_3\sin\theta)\,S + (K_4 + K_5\cos\theta + K_6\sin\theta)\,R + (\epsilon/a_i)\,F_eE,$$

where K_1, K_2, K_3, K_4, K_5, and K_6 are constants; a_s is the absorptance for the incident radiation of the sun; ϵ, the total hemispherical emissivity of the satellite surface at ordinary temperatures; θ, the angle corresponding to the satellite's entry into the earth's shadow; R, the earth reflectivity constant; and S and E are the solar and earth emission constants, respectively.

Thermal simulator reproduces components of flux

The 26 zones of the thermal simulator are programed and controlled to reproduce the different components of the flux, with each zone having a different set of constants. Input signals from stabilized, temperature-compensated thermopile radiometers in each zone are amplified and added to the set point terms, together with a bias, to provide an error signal. This signal controls motor-driven powerstats that keep the incident flux at the desired level.

The thermal constants are individually set on potentiometers. The multipliers of S and R are evaluated continuously, with sums of the terms allowed to assume only values greater than zero. For all values of θ yielding negative sums the multipliers are set to zero.

Sine-cosine potentiometers with variable-speed drives generate sinusoidal factors. Switches on these drives are set to drop the S multipliers to zero at times corresponding to the satellite's entry into the earth's shadow. Programing is provided for a minimum orbit period of 80 minutes and a maximum of 180 minutes.

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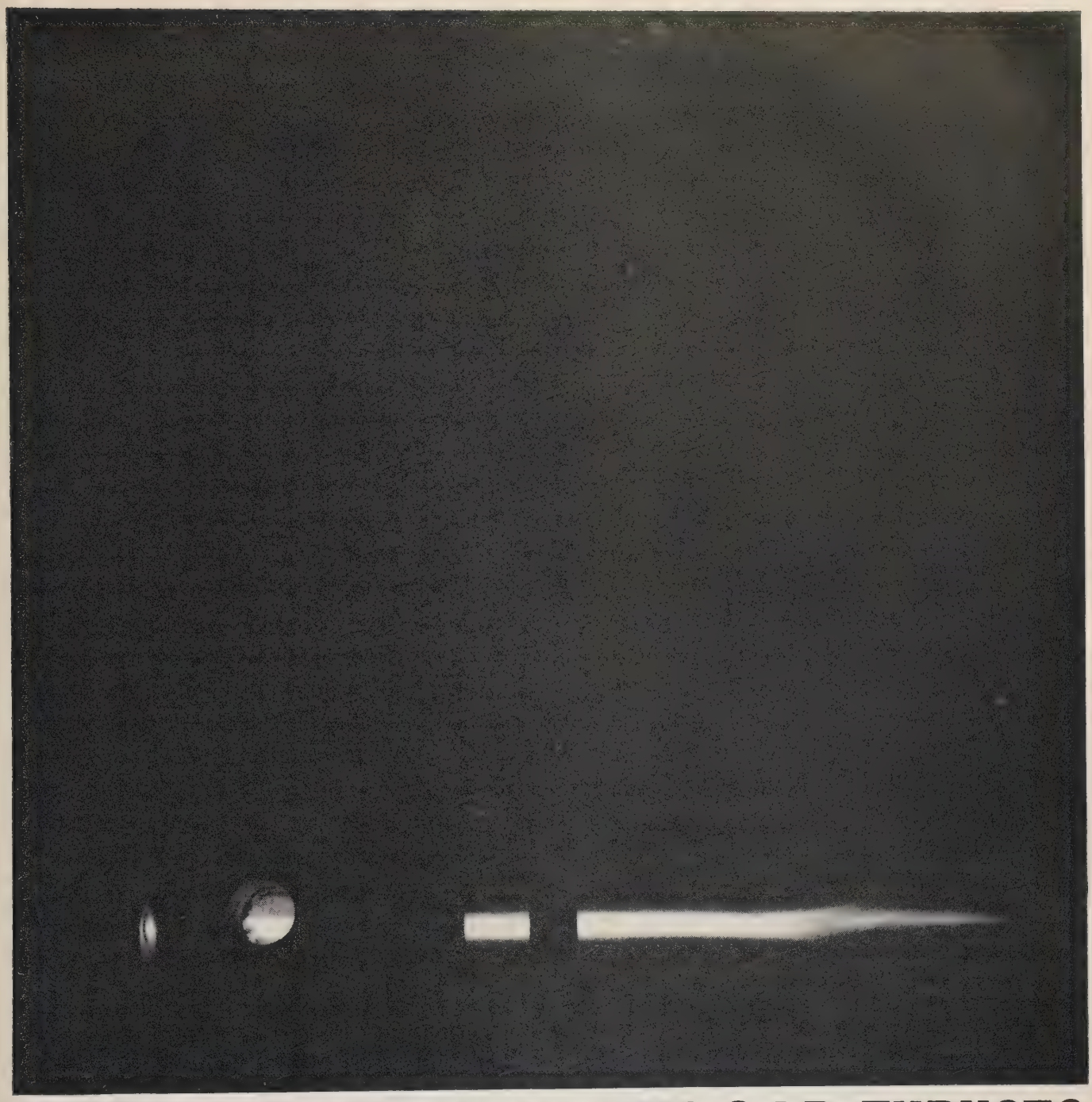

WHAT'S SO HOT ABOUT THIS 3 LB. THRUST?

It is a plasma jet, formed at more than 18,000° F., and accelerated in a magnetic field to triple its specific impulse. It is being developed in Northrop's Space Propulsion Laboratory as a propulsion system for maneuverable satelloid vehicles and spaceships. Its measured 3-pound thrust and high efficiency make it a leading candidate for the first true space drive.

In space, where gravity and friction are forgotten and acceleration time is relatively long, low-thrust, high-impulse engines like this offer a much more promising approach to space travel than most other types of propulsion. By looking at this theoretical problem from a solid, engineering point of view, Northrop bids fair to revolutionize space propulsion.

Northrop's approach to magnetogasdynamics is reflected in almost every phase of space technology. Wherever men, machines and space are coming together, Northrop techniques and experience are helping to find solid, practical answers.

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The U.S. Government looks to Ryan Electronics as a major source for Doppler navigators. Elsewhere in the Free World, other weapon systems developers are installing Ryanav equipment in aircraft for service under the North Atlantic Treaty Organization. **Ryan Electronics - Ryan Aeronautical Company, San Diego, California.**

RYANAV DOPPLER NAVIGATORS NOW IN PRODUCTION: AN/APN-97A Helicopter Ground Velocity Indicator, AN/APN-122(V) Doppler Navigation Set, AN/APN-129(V) Doppler Navigator for U.S. Army Fixed-Wing Aircraft, AN/APN-130 Helicopter Hovering & Ground Velocity Indicator. *TRADEMARK

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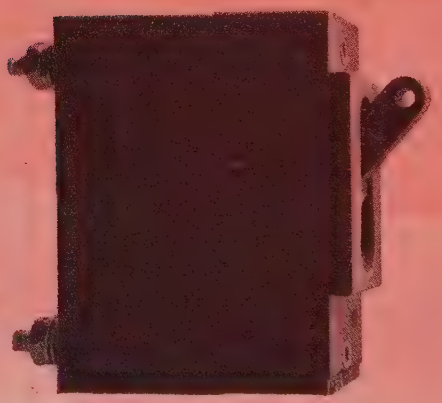
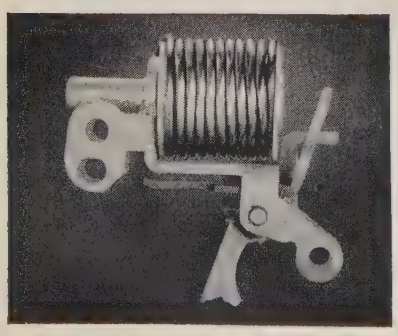
"The next voice you hear . . ." from the Mercury vehicle in orbit will come from equipment like these UHF and VHF transceivers built by Collins Radio.

NO HIGH-AMBIENT DE-RATING!



HEINEMANN CIRCUIT BREAKERS HOLD THEIR RATING AND TRIP POINTS AT ANY TEMPERATURE



Here you see the overload-sensing element of a Heinemann circuit breaker. Its unique type of magnetic actuation is functionally independent of temperature effect. Operation is based on actual load current —not on current-produced heat, as is the case with thermal-type devices. Consequently: current ratings hold constant at 100% nominal value, set trip-points stay fixed at specified overload percentages regardless of the ambient. Performance is always predictable, consistently dependable. Think about it: wouldn't your equipment gain added reliability with such built-in, temperature-stable protection? The Heinemann *Circuit Breaker Engineering Guide,* Bulletin 201, has all the technical details you'll want to know. Write for a copy.

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HIGH TEMPERATURES, RADIATION RESISTANCE, DENSE PACKAGING CLAIMED FOR PNEUMATIC COMPUTER

Operating temperature range of —100 to 2000 deg F is foreseen by Kearfott for its developmental pneumatic computer. The company says the feasibility models it has built point not only to high thermal performance but also to immunity from ionizing radiation (no electronic or solid-state components are used) and very dense packaging (the computer elements don't radiate heat).

The pneumatic digital computer, says Kearfott, could be the answer to the problem of cooling guidance equipment in re-entry and boost-glide vehicles as well as in advanced aircraft. It can perform all digital functions—counting, logic switching, and memory—without the risk of damage caused by faulty power-supply regulation, temporary open or short circuits, or overloads.

PNEUMATIC EQUIVALENT OF FLIP-FLOP

Key element of the pneumatic computer is the pneumatic equivalent of a flip-flop, which operates on compressed air or some other gas and has a 10-usec switching speed. In pneumatic circuitry, a diode is simply an orifice operating above critical flow (i.e., with gas flowing through it at or above Mach 1). Pressure disturbances upstream of the orifice propagate downstream through this orifice and only in the forward direction. A resistance is also an orifice or capillary, so that diode logic circuits are made up of orifices and capillaries of various sizes.

A plenum chamber provides the pneumatic resistance; the inductance is produced by a long tube whose diameter is large enough to keep viscous losses within limits. To convert pneumatic signals to electric ones, Kearfott uses a moving shuttle ball that is located inside the cylindrical flip-flop housing and has four tubular connections. For the actual signal conversion, the position of the moving ball is sensed by a coil, capacitor plates, or contacts imbedded in the cylinder wall. To convert electric signals to pneumatic ones, the ball shuttle is impelled magnetically or electrostatically.

LAYERS OF PERFORATED PLATES

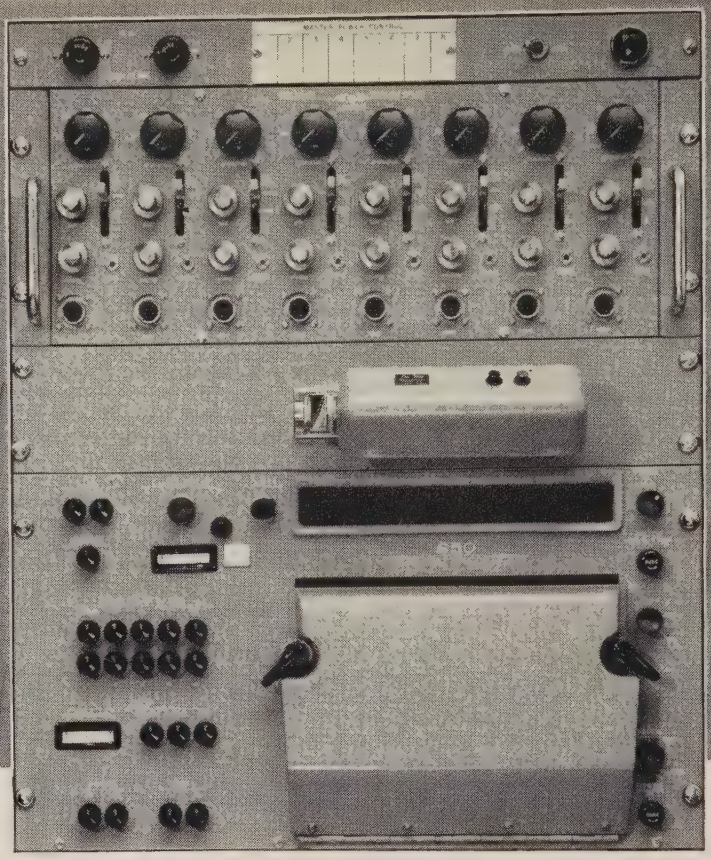
Kearfott believes the greatest possible packaging density can be reached by forming the computer elements and circuits in layers of perforated plates. Interconnections are made by drilling holes through grooved matrix plates at intersections. The basic material could be a ceramic or a high-temperature alloy.

Typical packaging densities of 2000-4000 bistable elements per cubic inch are possible, say Kearfott engineers, so that a medium-size, general-purpose computer would need only 5½x5½x1 in. In this small size, the company points out, a guidance system computer could be built into an inertial platform or a processing module into a satellite telemetry system. With data from successful experimental pneumatic circuitry and elements under its belt, Kearfott is going ahead with the development of a complete computer.

Grumman let a contract to IBM's Federal Systems Div., Rockville, Md., to build and flight-test models of an advanced satellite data processing and memory system for the orbiting astronomical observatory (OAO) that it is developing for NASA. Orbiting at around 500 miles, OAO will gather data on the relative positions of space bodies, the prevalence of various elements in space, the nature and amount of cosmic gas and dust, etc. Data from the sensors on the vehicle will be processed into pointing commands for servoing the on-board telescopes into alignment with various stars or planets and will also be stored in the memory system. A smaller command memory will be included for storing instructions from the ground during the 10-minute periods that OAO will be in radio range of ground stations.

The main memory reportedly will have a storage capacity of over 200,000 bits, all of which can be read out and transmitted to an interrogator on the ground in about 7½ seconds. Because of the very high reliability requirements (the system is expected to operate for a year or more in orbit), a lot of redundant circuitry will be used

DC to 5000 cycles over an amplitude of 4″ peak to peak



NEW SANBORN "650" SYSTEM OFFERS DIRECT READOUT, 8 TO 24 CHANNELS, ALL SOLID STATE CIRCUITS, FOR RACK MOUNTING OR INDIVIDUAL CASES.

Here's the *one* system that lets you record inputs from DC to 5 KC within 3 db at 4″ peak-to-peak amplitudes, without changing galvanometers. The "650" system consists of an 8-channel medium gain, general purpose amplifier unit driving a high speed, high resolution optical oscillographic recorder. It can be easily built into your system, packaged in a mobile cabinet or housed in individual cases. The single-chassis, 7″ high amplifier module has 8 separate channels, *complete from floating and guarded inputs to galvanometer outputs;* each channel comprises a front end modulator and input transformer, carrier amplifier, demodulator, filter and driver amplifier. Power Supply and Master Oscillator Power Amplifier are built-in. All amplifier elements are plug-in transistorized units for easy servicing.

Immediately readable recordings are made on 8″ wide daylight-loading ultra-violet-sensitive charts which require no chemical development. Features of the 12¼″ high recorder unit include 9 electrically controlled chart speeds from ¼″ to 100″/sec; calibrated monitoring screen; automatic trace identification and timing lines at 0.01 or 0.1 sec. intervals; amplitude lines spaced 0.1″ apart which can be blanked from ¼, ½, ¾ or all of chart. Recorder is available with an 8-, 16- or 24-channel galvanometer block which is then equipped with the number of galvanometer elements desired by the customer. Both the Recorder and Amplifier are also available as individual units for use with other equipment.

SENSITIVITY 20 mv input gives 8″ deflection; 12 attenuator steps to X5000, smooth gain control.

INPUT RESISTANCE 100,000 ohms all ranges, floating and guarded; DC source resistance must be kept below 1000 ohms on mv ranges only.

COMMON MODE PERFORMANCE Rejection at least 140 db at DC, tolerance to ±500 volts, max.

GAIN STABILITY Better than 1% to 50° C. and for line voltage variation from 103 to 127 volts.

LINEARITY 1½% of full scale (8 in.)

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MONITOR OUTPUT On front panel; provides ±1v full scale across 100,000 ohm load

POWER REQUIREMENTS 103-127 volts, 60 cycle AC; 625 watts

Contact your Sanborn Sales-Engineering Representative for complete specifications and applications engineering assistance. Offices throughout the U. S., Canada and foreign countries.

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in the memories and the other electronics. Microscopically small, two-hole ferrite cores will populate the memory modules. Non-destructive readout will be used to preserve the stored data even though they are read out repeatedly, as would be the case if transmission to ground were disrupted or unclear.

JET TANKERS DOUBLE IN BRASS

K-135 jet tankers are being outfitted for anti-sub surveillance by Ling-Temco Electronics under a $12 million contract. Reportedly the company is working on a common installation of radar and Mad devices that would complement each other—if a blip is picked up that the operator suspects is a sub, it could be verified with the Mad gear by the change in the earth's magnetic field that it produces.

USAF normally has a large number of jet tankers aloft on routine refueling missions for SAC and other commands, so it probably has decided that it might just as well get more use of these far-ranging tankers by outfitting them for regular radar surveillance and ASW detection.

PRECISE ALTIMETER FOR MANNED SPACECRAFT CLAIMED

The first practical method for determining precise altitude in manned spacecraft is claimed by Sperry Gyroscope. Long-range altimetry, Sperry says, is a vital requirement for such craft. Even a narrow drift in altitude from the prescribed re-entry "corridor" could destroy the vehicle. Up to now, says Sperry, the best conventional space altimeters could give you long-range, long-time accuracy only in thousands of feet. In contrast, Spiral (*S*perry *i*nertial *r*adar *a*ltimeter) is accurate to within several hundred feet, even at 200 miles above the earth.

Melpar has been picked by Autonetics to produce high-reliability assemblies and modules for the electronic systems in Minuteman. The circuit board assemblies and modules will be used as "building blocks" in the inertial guidance, flight control, and ground checkout systems for the Minuteman. Melpar was chosen after a careful screening of detailed bids from some 27 firms. Autonetics will hand over to Melpar components it has stockpiled during a two-year program aimed at upgrading the reliability of semiconductors to be used in the ICBM and involving 13 components manufacturers (see S/A, *"Getting Ultra-Reliable Components for Minuteman," Jan. 1961, p. 143*). Autonetics will also turn over to Melpar the advanced circuit-board assembly techniques it has developed during the formative stages of the $20 million program.

ELECTRON CURRENTS IN CRYSTALS STUDIED FOR AFOSR

Electron currents in crystals are being studied at Martin in an effort to come up with new basic electronic concepts. USAF's Office of Scientific Research will provide $50,000 for this study for a two-year period.

ALKALIHALIDE CRYSTALS STUDIED

Martin researchers are first looking into the behavior of electric charge carriers in alkalihalide crystals. Their aim is to get extremely accurate measurements of mobility and other characteristics of these carriers over a wide range of temperatures— from ambient down to near absolute zero. The techniques being developed should be applicable to the development of organic semiconductors, which many believe show promise of providing a less expensive material for aerospace electronics.

The nuclear-powered Enterprise will get the first operational installation of Bell Aerosystems' automatic carrier landing system. Nine other carriers will get the system between '62 and '64.

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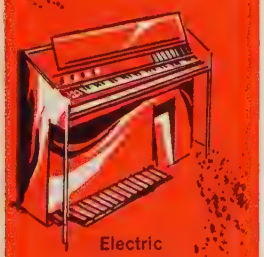
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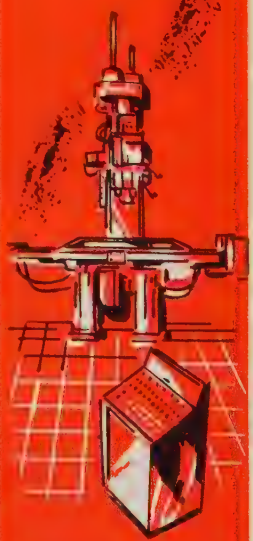
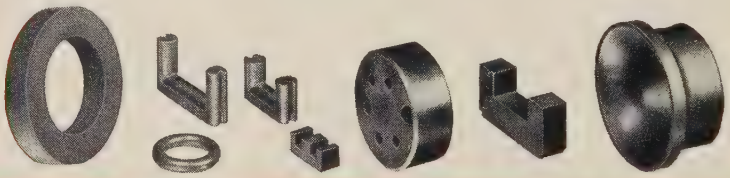

Automatic Machine Tools

From the broad line of Allen-Bradley *quality* ferrites, more and more designers are finding they can obtain the exact characteristics to meet their specific needs. Allen-Bradley's precise quality control methods insure continuously uniform electrical and mechanical properties—and A-B has the facilities for supplying ferrites in quantity. Listed below are a number of areas in which A-B ferrites have helped the manufacturer to reduce the product size or weight, or cost, and frequently the performance has been improved. If you have problems along this line, please let our engineers work with you in solving them.



APPLICATION	A-B FERRITE	PREFERRED CHARACTERISTICS
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Convergence Cores	W-01	Low residual with large gap
I. F. Transformers	R-02	Low losses at low amplitudes. Good temperature stability of permeability
R. F. Tuning Coil (fixed or permeability tuned)	R-02	Low losses. Temperature stable permeability, minimum hysteresis for permeability tuning
TELEPHONE SYSTEMS Interstage and Matching Transformers	W-03	High permeability, low losses
H. F. FLUORESCENT LIGHTS Loading Reactors	W-07	High flux density
Transformers	W-04	High permeability, low losses, high B_{max}
ELECTRIC ORGANS AND HI-FI STEREO Oscillator Inductors	W-03	High permeability, temperature stable, linear B vs. H
Output Transformers	W-04	High permeability, high B_{max}, low losses
AUTOMATIC MACHINE TOOLS Magnetic Amplifiers	R-03	Rectangular hysteresis loop, high B_{max}
Logic elements for high-power levels	R-03	Rectangular hysteresis loop, high B_{max}
Matching Transformers	W-04	High permeability, low losses, high B_{max}
MOBILE POWER SUPPLIES Static Inverters	R-03	Rectangular hysteresis loop, high B_{max}
RADAR, MISSILES Pulse Transformers	W-04 R-02 (for short pulses)	High pulse permeability, high B_{max}, low losses
PERMANENT MAGNETS	M-01	High energy factor Good mechanical strength

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The use of natural waveguides in the various layers of wet and dry rock beneath the earth's soil crust is being pushed for future reliable, low-frequency communications networks to back up primary communications links in the event of nuclear attack. Sylvania, in particular, which was in on the original development of the shallow-current underground communications for Minuteman's radio launch control, wants to see this technique furthered. According to Dr. R. L. San Soucie, of Sylvania's Amherst Labs, "there is underway today a tremendous effort to develop communications techniques to stretch our concepts of usable frequency spectra. . . . USAF is working on the underground technique as well as [on] VLF satellite systems, millimeter wave and optical communications."

NRL's work on a VLF satellite system, San Soucie adds, is designed ultimately to provide an alternate route for operational messages to ships and subs at sea. Lofti I, a Navy experiment, was launched by NRL into a highly eccentric orbit but managed to receive 18-kc signals from the Navy's 30-kw radio station at Panama, providing "very useful information for further VLF and communications satellite development."

SYLVANIA LAB IS STUDYING OPTICAL COMPUTERS

Optical computers using glass-fiber transmission lines and quantum electronics storage techniques are being studied at Sylvania's Computer Development Lab. Long glass fibers, which are extremely flexible and easy to use, are expected to make excellent transmission lines for such systems. Their low cost compares favorably with the relatively expensive plumbing that would be needed for microwave computers, says Sylvania's L. C. Clapp. The reason why both optical and microwave computers are being studied in the first place lies in the promise of high-speed performance. Light attenuation doesn't appear to be a limiting factor in the optical device. Actually, as Clapp points out, the only light attenuation in passage through a fiber is due to absorption by the glass and is generally less than one per cent of the energy per inch of travel.

Cross-talk between adjacent transmission lines is prevented by coating the optical fiber with a thin glass film of lower refractive index. Quantum-level memories, says Clapp, would go well with optical computers, as electron transitions from one quantum level to another takes place at about 10^{-8}-10^{-9} usec at optical frequencies.

CONTRACTS FOR COLLINS AIRBORNE DME MADE UP OF SMALL INDICATOR AND 37-LB TRANSMITTER-RECEIVER

Over $3 million in airborne DME contracts was received by Collins Radio in recent weeks. Collins' DME system consists of a small indicator and a 37-lb transmitter-receiver. Installed in the instrument panel, the mileage indicator keeps the pilot continuously informed of his exact distance to a given ground station. The system operates by sending coded interrogation signals to the ground station, analyzing the replies, and converting them into a visual readout on the pilot's panel. One of the problems as yet is the relative scarcity of automatic DME ground stations, on which the system is completely dependent. FAA now operates 344 stations and plans to have 833 in service by '66. To these must be added the 225-230 military ground DME stations that are compatible with the civilian equipment.

FAA TO ADD DME STATIONS

Sperry-Phoenix will provide flight control systems for Boeing's 727s under a $7 million award. An advanced version of the Sperry SP-50, already proven in flight tests, will be used. Boeing has specified separate packaging of the electronic controls for pitch and roll and for a dual yaw damper system for the new system.

ITT-Federal reports the completion of the initial hardware design phase leading to an experimental satellite-borne communications repeater. Company engineers

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say that the final satellite communications package will have a bandwidth wide enough to handle either multi-channel telephone traffic or a TV channel. The repeater will be able to link any two suitably equipped stations within the line of sight of the satellite. Stations in Europe and South America, for instance, could be hooked up. ITT believes such a circuit would be a stepping stone to a comprehensive world-wide communications system.

BOTH SATELLITES AND CABLE NETWORKS IN FUTURE COMMUNICATIONS SYSTEMS, ITT ENGINEERS BELIEVE

LAND CABLES WILL ALWAYS BE NEEDED

A survey of opinion among several top ITT engineers shows that they generally agree that future communications satellites and existing cable networks will play complementary roles. Although, according to Frank Fairley, technical adviser to ITT-Federal, "the attention of communications engineers is focused on the more exotic forms of long-distance communications systems, freedom from interference . . . is likely to justify long-distance submarine cables for main global communications links for many years . . . Even when all the probers of satellite launching and performance have been solved, cable links will take their place in the world network on an equal or better performance basis [with] the best satellite circuits . . . " Fairley adds that a land cable network will always be needed, regardless of whether it must link up with coastal landings or satellite transmitters.

Giant horn-shaped receiving antennas for BTL's Project Echo will be produced by Telecomputing. This contract, the first let for the passive global-communications system, totals well over $1 million, says W. R. Whittaker, Telecomputing's president. He also notes that the company recently received a contract from Bell Labs for Nike-Zeus anti-missile missile discrimination and tracking antennas and anticipates getting the contract for antennas for Project Advent.

AC BY DIRECT CONVERSION OF HEAT TO ELECTRICITY

General Dynamics' General Atomic Division is studying the possibilities of producing very-high-frequency AC by direct conversion of heat into electricity under an RADC contract. The $60,000 program calls for experiments with a cesium-cell thermionic converter to determine the conditions under which the cell can produce AC, mainly at frequencies around 50 mc. Design parameters governing frequency range, stability control, power densities, and efficiencies will also be studied.

RADIO INTERFERENCE TO BE CONTROLLED

A tri-service program to analyze and eventually control radio interference here and abroad got a big boost with the award of a contract from USAF's Electronic Systems Division to Armour Research Foundation for technical support. Armour will set up a temporary center that will serve as the hub for DOD's compatibility program. There electronics and mathematics specialists will develop methods for processing and analyzing radio interference problems. The permanent center will be operated by Armour at the Naval Engineering Experiment Station, Annapolis, Md.

A built in self-test feature now makes it possible to be certain that a missile's guidance gyros are in working order just before the bird leaves the launch pad, says Norm Zatsky, director of U.S. Time's Instrument R&D Center, Irvington, N.Y. The self-test design enables the gyro motor to give a signal showing it is up to speed. A special torquing device built into the housing makes it possible for a signal input to monitor the output performance.

COMMUNICATIONS UNDER ANY CONDITIONS

Consistent with its policy of thinking and working years ahead, ITT Federal Laboratories has been concerned with the communications problems which might arise in extreme emergencies. That, surely, is when the need for rapid interchange of information would be greatest, and where the system and equipment would have to be absolutely reliable.

Providing airborne guidance and communication systems capable of outstanding dependability under even the most unfavorable environmental conditions, is a significant aspect of ITT's past and current record. Instrument landing systems, direction finders, distance measuring equipment, and guidance systems for some of our most successful missiles are but a few of ITT's developments in this field. Today, Company-sponsored research activities responsible for many of these accomplishments have been greatly expanded to anticipate the increasingly critical communications needs of the future.

To the military and to industry, ITT Federal Laboratories offers a unique combination and continuity of skills, already existing as a highly trained team, for performance of complex projects throughout all stages from original concept to the delivered system.

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AVIONICS ■ COMMUNICATIONS ■ SPACE AND MISSILE SYSTEMS ■ ELECTRONIC DEFENSE ■ PHYSICAL SCIENCES

A "gentlemen's agreement" is again being proposed by Western Electronic Show and Convention (Wescon) officials to all participating companies, covering two occupational diseases that tend to get out of hand at most of the large engineering conferences: personnel recruiting and company entertainment. Last year, a similar agreement proposed by Wescon was reasonably well adhered to.

In a message to all exhibitors this year, Wescon's management condemned prevalent recruiting practices and stated that "this kind of drum beating, which has blighted a number of important technical gatherings, is significantly missing from Wescon. No responsible organization takes advantage of the Wescon 'population' to launch unseemly personnel recruiting efforts. It remains apparent that aggressive recruiting of technical personnel has no place in a forum of scientific professionals, and we again ask that participants join in a 'gentlemen's agreement' to serve the electronic industry by eliminating this practice."

In its attack on convention partying, Wescon observed that "excesses in company-sponsored social functions can obviate the advantages for which [these functions] were planned. They can destroy the public image of an entire industry."

To make sure that parties and hospitality suites don't get out of hand, the Wescon management suggested that companies spend more time planning their social functions, that they send out invitations and admit only the invited, and that the number of people be restricted in accordance with the available room.

Wescon this year will be held in San Francisco's Cow Palace from August 22 to 25. The emphasis will be on radio-radar astronomy, with specific attention focused on microwave and optical masers parametric amplifiers, and the growing overall field of quantum electronics.

The feasibility of airborne ballistic-missile early warning is being studied by engineers at GE's Light Military Electronics Division. Preliminary calculations show that a one-megawatt-average-power radar would be needed. A TWT chain is being considered as the RF amplifier. The source of primary power for such a radar, LMED engineers suggest, could be an airborne nuclear reactor. An aircraft powered by a nuclear reactor would be able to hover on station for 24-hour periods, LMED estimates.

LMED is also studying the possibilities of a satellite-borne missile detector passive infrared. Large weight rules out a high-powered radar for satellites.

Ground BMEWs is limited in range by the horizon, GE points out, and an air or space system would overcome this limitation.

The only airline to have all its jets equipped with distance-measuring equipment is American. Recently FAA proposed that all civil jets carry this navaid. American's DMEs are made by ITT.

The inductor problem in microelectronics was summed up by G. C. Gaut, executive director of Plessey, with British wryness: "The inductor . . . remains a pillar of resistance" in high density circuit design. Surveying the status of microminiaturization in *British Communications & Electronics,* Gaut added that the inductor is perhaps the least important of circuit elements, "but it remains a major embarrassment . . . "

Ecko airborne weather radar will be produced in this country by Wilcox Electric under a long-term contract with Ecko Electronics. The British radar weights 57 lb total, has a 150-mile range, and includes a 24-in. diameter antenna and a bright display.

Optical masers are being used in eye surgery experiments by TRG, Syosset, N. Y., and New York University. The device's high energy concentration in a small volume has been put to use to repair retinal detachments by "cauterizing the retina-choroid interface." In non-medical language: The concentrated energy from the laser is used to repair the separation of the retina by "welding" it to the choroid.

TRG has performed a number of successful experiments on animals using a pulsed ruby laser source. Either fiber optics or an optical train can be used to channel the energy to the desired spot, it says. Its researchers see a number of other surgical possibilities for lasers—"wherever you need to concentrate a lot of energy into a very, very small volume."

TRG has also been working on a USAF study contract covering solid and gaseous masers. It has built a ruby laser similar to the one first devised by Hughes Aircraft as well as two infra-red masers. One of the latter has a self-discharged, pumped krypton-mercury vapor element that emits at six microns; the other uses a cesium vapor cell pumped by a continuous helium arc to emit seven-micron radiation. TRG is also believed to be studying the possibilities of using lasers for underwater communications.

The Stark effect is being tried in some research labs as a means for frequency-modulating the output of optical masers. Essentially a changing transverse electric field is used to vary the energy difference between two levels of interest in the maser material to produce hyper-fine outputs. The question that remains to be answered is, How quickly can these levels be changed? The answer will determine the modulation bandwidth, a figure of prime interest to those who would like to use the laser in optical communications.

There are natural times for interaction between the radiation field and the excited atoms in the maser. Researchers tend to think that these times are rather long and therefore suspect that the bandwidth attainable by Stark-effect modulation is quite narrow.

Several other effects (e. g., the Zeeman and Kerr effects) are also being studied as possible modulation methods for the laser. Basically the types of maser modulation fall into three categories:

- modulation of the population state inversion by varying the pump signal;
- modulation of the feedback energy;
- modulation of the light source.

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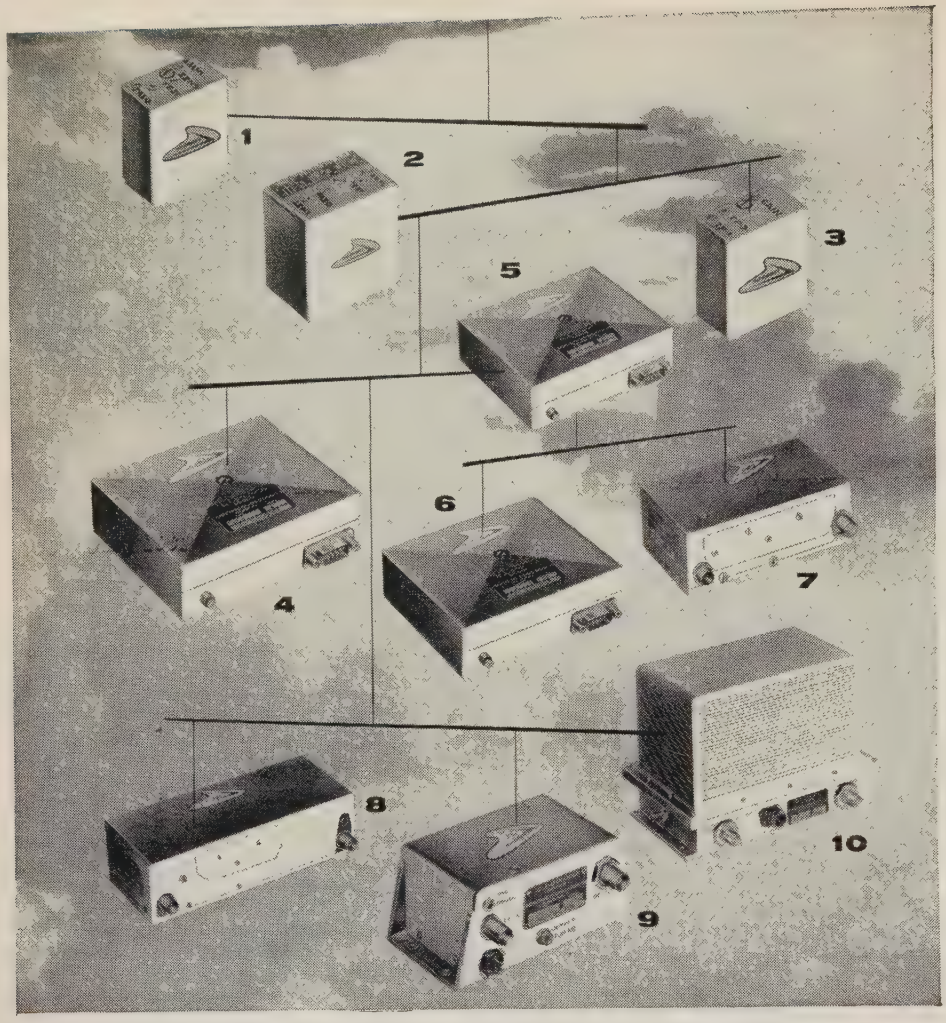

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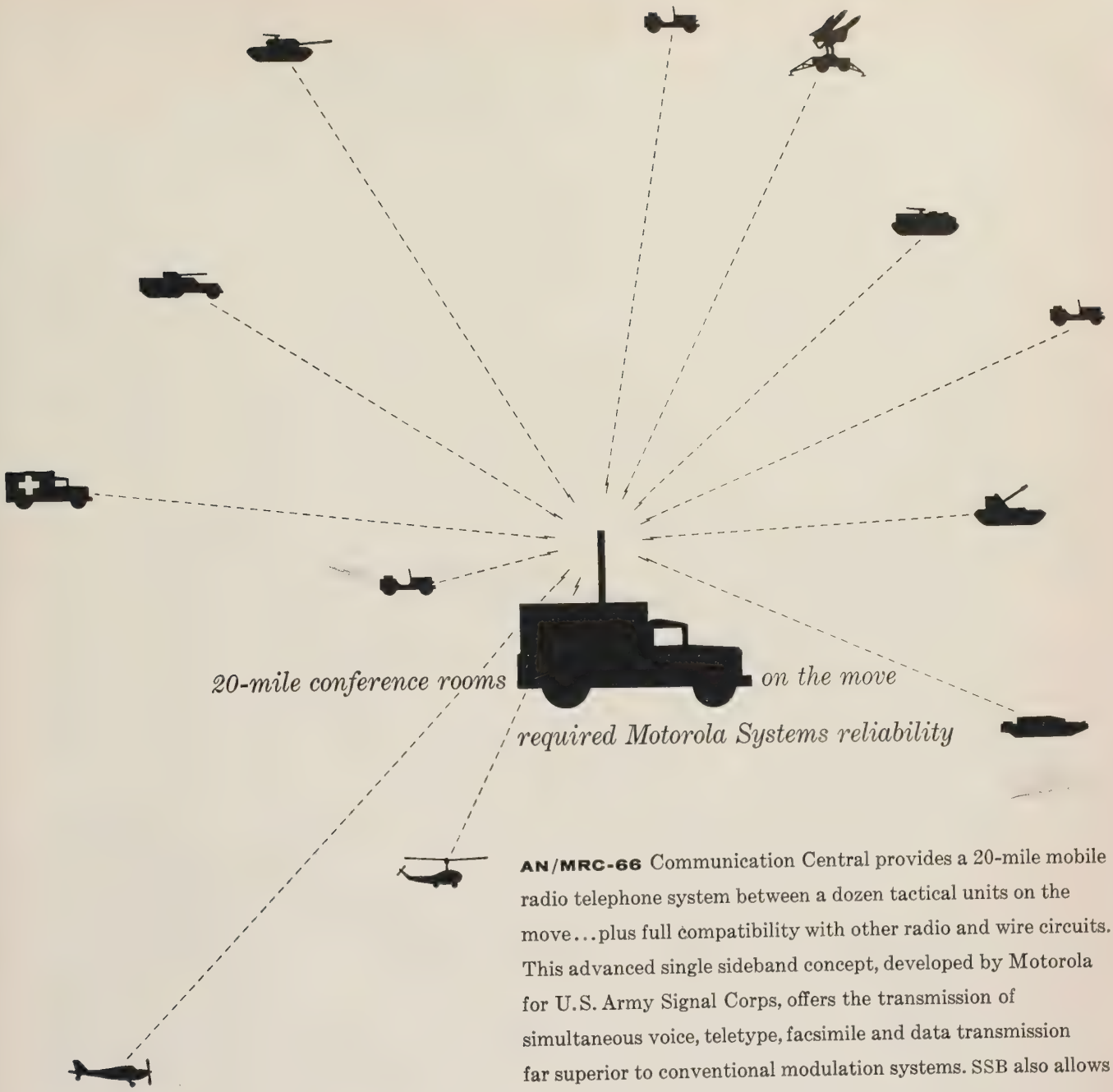

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They have not changed since 1956, when the Visicorder principle of oscillography made immediate readout of high frequency data possible for the first time.

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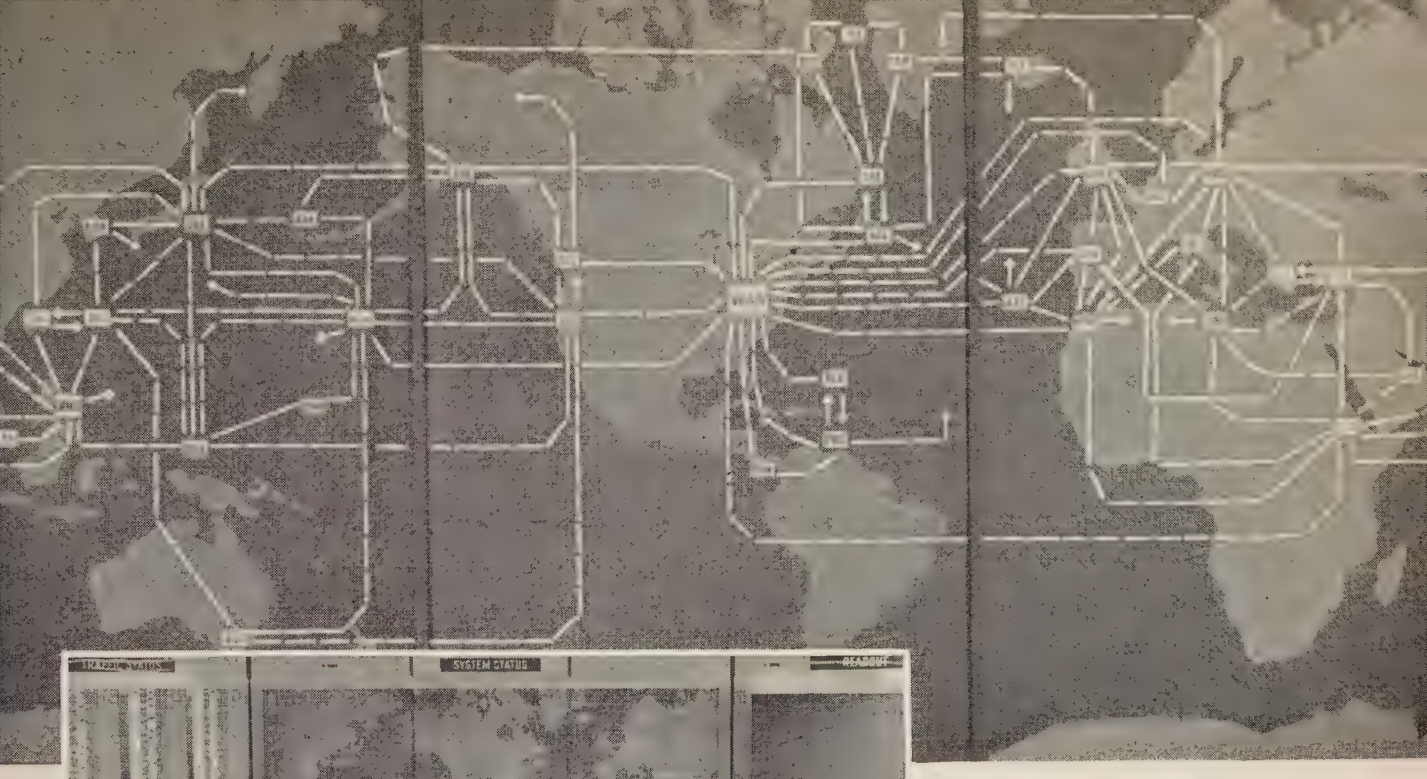

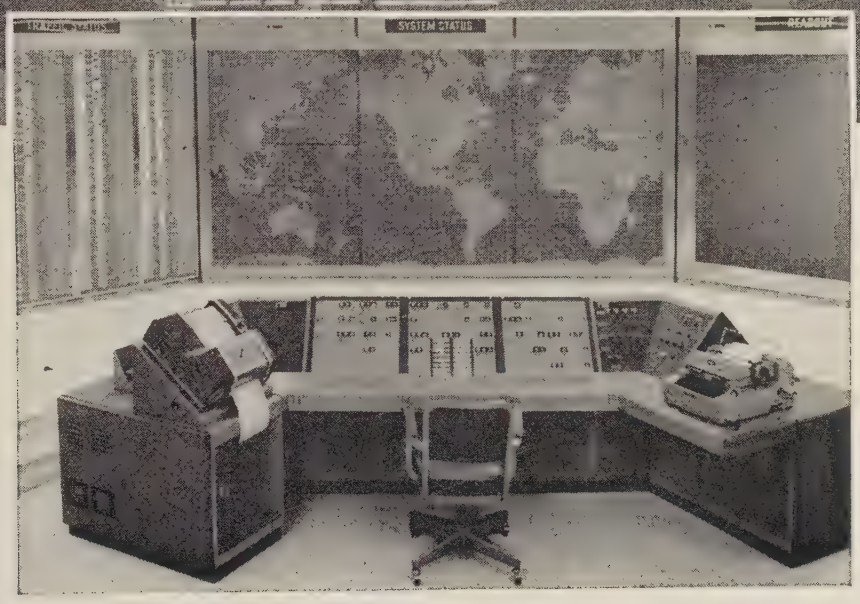

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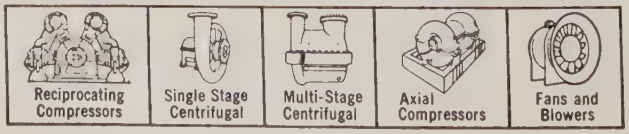

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NEW FROM WESTINGHOUSE

ULTRAVIOLET COMMUNICATION SYSTEM FOR SPACE

Westinghouse scientists are developing a new kind of space communication system. Called Ultracom, it will use a beam of ultraviolet light, modulated to convey information.

In a space vehicle, the electrical supply and volume are limited. Here Ultracom will have many advantages over radio. Because UV frequencies are higher than radio—about a million times—signals are disturbance free and can be sent farther with less power: 50 million miles, for example, with a radiated power of 1 watt. Ultracom will require far less area for antennas, and reliability will be high because of equipment simplicity.

Westinghouse scientists were the first to achieve communications by ultraviolet. Development of the Ultracom system for space application is another example of how Westinghouse is *First* with the Future. Defense Products Group, 1000 Connecticut Avenue, N.W., Washington 6, D. C.

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INSTALLED IN AN OPERATIONAL FIGHTER

NEW PROOF OF LITTON'S CONTINUING CONTRIBUTIONS TO THE DEVELOPMENT OF INERTIAL NAVIGATION IS FURNISHED BY THE LN-3-2B AUTOMATIC NAVIGATOR THAT IS NOW BEING INSTALLED IN CANADA'S CF-104 FIGHTER.

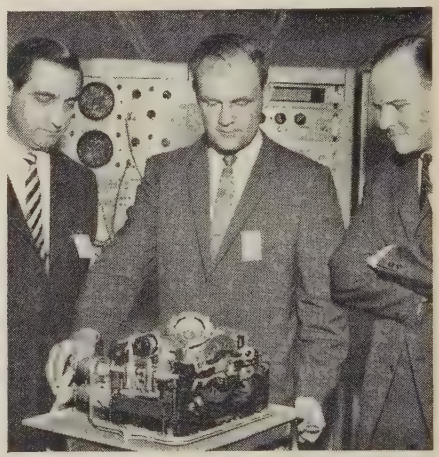
Three-hundred-and-sixty-degree freedom of aircraft maneuver on every axis is made possible by four-gimbal isolation of the Litton stable platform that keeps the system's accelerometers aligned in inertial space. Voltage signals from the accelerometers are transmitted to a computer where they are integrated to compute vehicle position components.

In addition, an adapter unit provides 27 outputs of pitch, roll and heading angles and ground speed to other equipment in the aircraft such as bombing computer and autopilot.

In flight, tight servo loops hold all sensitive elements of the stable platform at null regardless of acceleration. Any relative motion between the gyro case, which is fixed to the platform, and the floated gyro rotor, which is fixed in space, is sensed and corrected to keep the platform including accelerometers oriented to vertical and north. Any acceleration along an axis produces an accelerometer torquer current which is proportional to the applied acceleration. This torquer current holds the accelerometer at null, and the same signal is transmitted to the navigation computer.

Another indication of the scope and caliber of Litton inertial engineering is the new combined doppler and inertial navigation system being produced by Litton Systems for the Lockheed P3V-1 anti-submarine patrol aircraft. The inertial system continuously measures accelerations along the two horizontal axes and computes velocity components and aircraft position in latitude and longitude. Velocity information from the AN/APN-122 doppler radar is used in the inertial navigation system to optimize system performance.

A half dozen other Litton inertial navigation systems have been successfully developed to the operational phase. Still others are now in earlier phases of development.

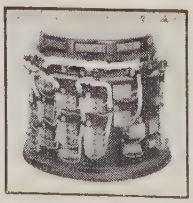


EXAMINING LN-3 STABLE PLATFORM UNDER TEST AT LITTON'S WOODLAND HILLS, CALIF. FACILITY ARE L-R: VIC SYMONDS, LITTON-CANADA; P. LUTH, LITTON-CALIF.; D. BELYEA, ODP.

These programs are being carried forward by engineers specializing in inertial navigation and related techniques. By engineers with their own long-range plans, and the ability to make important contributions to inertial engineering. By engineers who prefer engineering to paper work. By engineers willing and able to see a job through from concept to product.

Are you specially qualified in inertial equipment, computers, data processing systems, tactical data systems, displays, advanced communication techniques? Write today to Donald Krause, Research & Engineering Staff, Litton Systems, Inc., 336 No. Foothill Road, Beverly Hills, California.

Qualified applicants will be considered regardless of race, creed, color or national origin.



LITTON SYSTEMS, INC.
Beverly Hills, California

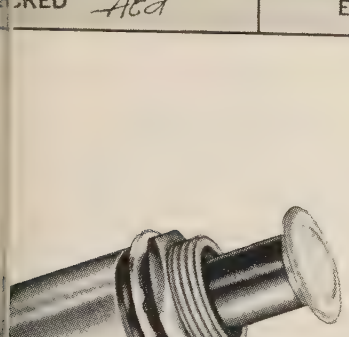
DIVISION OF LITTON INDUSTRIES

No. 144 on Reader Service Card

ENGINEERING NEWS - #10

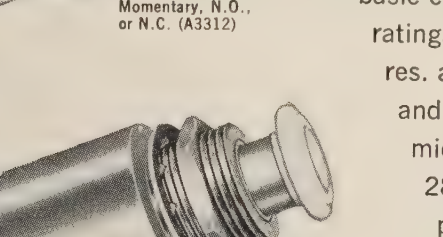
LIGHTED PUSHBUTTON SWITCHES

CKED *HEd*	ENGR. *W.E.M.*	CONTROL SWITCH DIVISION

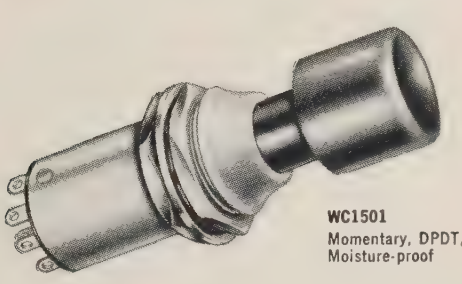


A3311
Momentary, N.O., or N.C. (A3312)

A3298
Momentary, SPDT



J6230
Push-Push, SPDT



WC1501
Momentary, DPDT, Moisture-proof

These five models indicate only a part of the full line of SWITCHLITES made by Control Switch Division. These units combine both switch and indicator light in a single rugged, compact assembly. They are available with momentary, push-push, or push-pull snap-action, having a positive feel. There are eight basic case styles, 20 circuit arrangements. Switch ratings from 2 to 20 amps, ind. or 10 to 20 amps, res. at 28 VDC—depending on switch type, circuit, and required operating life. Switchlites use a midget flange base MS25237 lamp, 6, 14 or 28 volts. Choose from five styles of plastic pushbuttons in standard transparent and translucent colors.

In other words, almost any requirement you may have for a compact lighted pushbutton is available in a standard SWITCHLITE from Control Switch Division. For more technical data write for free literature.

TWINLITE . . . lights in 2 colors

Here is a low-cost lighted pushbutton containing two lamps which may be individually circuited. Plastic lens is 1″ x .740″, and comes in one solid color, two-color split, engraved or with a nameplate slot. Select double-pole or triple-pole switching with push-push, momentary, or solenoid-held action. TWIN-LITE mounts individually with barriers, in rows, or a matrix.

Manufacturers of a full line of switches, controls and indicators for all military and commercial applications. All standard units stocked for immediate delivery by leading parts Distributors.

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A Space/Aeronautics Survey

Growing trend to

airborne digital computers

A SPACE/AERONAUTICS SURVEY shows some forty airborne digital computers in being, many of which are in actual operational use and others slated for advanced vehicles that have yet to fly. Almost all firms making the tabulated computers have newer more sophisticated designs "in the works". The success of these early generation machines, coupled with progress in microminiaturization and logic and memory designs, practically assures the use of digital computers in all future air and space vehicles that will have to perform complex functions. Apparent trends are to smaller and more reliable, no-moving-parts designs and, in many instances, to higher and multi-speed systems and larger capacity and more versatile memories. (Data too late for inclusion in table and notes shows: (1) A one lb, 20 cu in, thin film computer just developed by Hughes; (2) the RW-33, a 60 lb, 0.6 cu ft, real time control, magnetic drum computer by Ramo-Wooldridge; (3) three microminiature airborne digital computers by Burroughs and (4) announcement of progress in developing a molecular electronics, 15 lb, less than a third cu ft digital computer by Westinghouse.)

CONCURRENT DEVELOPMENTS in miniaturization and digital technology have led to the most remarkable recent achievement in aerospace electronic design: the vehicle-borne digital computer. Less than a decade ago, the idea of carrying such a device in tactical and strategic aircraft existed only in the minds of the most visionary optimists. Nobody thought of carrying one in a space probe.

Today, some five years after the first production airborne digital computer came off Hughes Aircraft's assembly line, the digital computer is firmly established as an essential element of future advanced aerospace vehicles (*Tables I & II*). According to a recent analysis by a large aerospace electronics firm, the market for airborne digital computers was $80.2 million in 1959 and will grow to $187.5 million in 1964.

To date, the prime functions of airborne digital computers have been in navigation, guidance, and weapon control. In addition, many computers are used for display generation, air-data computation, test-data processing, target and threat evaluation, cruise control and fuel management, and for diagnostic and functional checking of their own elements and of other units of airborne electronic systems. Specialized applications have evolved in electronic countermeasures and photo and electronic reconnaissance.

In relation to the overall system of which it is a part, the digital computer serves as a unifying element. It ties together otherwise isolated subsystems into a single, integrated network. Its high speed allows the time-sharing of many of its functions among the subsystems. Where real-time operation is needed, as for flight control, a special high-speed loop can be built into the computer to handle the real-time computations while other computations proceed at lower speeds. Where various speed levels are needed, the computer can be designed with a number of such loops. The trend to adaptive autopilots in future aerospace vehicles is largely based on the appearance of miniature real-time digital computers.

Real-time operation and the emphasis on correlation techniques in data-gathering systems have led to

by James Holahan, Electronics Editor

the need for higher computer speeds. For large-scale systems, for example, Westinghouse Air Arm foresees 1,000,000 operations per second as a reasonable speed requirement within the next decade.

However, not all computing requirements will be on a large scale. Computer manufacturers predict a continuing need, especially in missiles and spacecraft, modest-speed and capacity systems of minimum size and weight.

Microminiature components and techniques have made the airborne digital computer practical. At the same time, the prospect of such computers in aerospace vehicles has furnished much of the impetus for microminiaturization. It's not surprising, therefore, that the airborne digital computer should reflect the latest miniature design and packaging techniques.

Hughes' Digitair was designed in 1955 around the subminiature tube mounted on plug-in printed circuit cards. Later computers use transistors and semiconductor diodes as the amplifying and switching elements. The next stage in the evolution of computer design is represented by passive thin film elements packaged with uncased transistor and diode chips.

The tunnel diode appears to have an assured future in high-speed airborne computers as both a memory and a logic element. Tunnel diodes are available now that can provide clock rates of at least 30 mc. Based on developments, tunnel-diode computers with 1000-mc clock rates are predicted.

To date, most computer interconnections have been made by conventional soldering methods. The trend in the latest designs is to go to welded connection for greater reliability, space savings, and lower assembly cost. For the most part, circuits are encapsulated to enable them to withstand the rugged environments.

The design of any computer naturally depends on the problems it must solve, on the versatility required of it, and on the environments in which it must operate. For this reason, the physical and operating characteristics of the airborne computers listed in the table and accompanying footnotes cannot be compared meaningfully on a quantitative, point-to-point basis. Evolutionary design improvements become apparent when you study the differences between members of computer families like the three Arma computers, Hughes' computers, Litton's computers, and Westinghouse's computers.

One of the surprising facts about airborne digital computers is that often they are built to give only approximate solutions, though inherently they are capable of exact solutions. The reason for this is that the simpler design costs less and is more reliable. At the outset of the design phase, systems engineers often find that approximate solutions will do the job with all the accuracy they need, while exact solutions may demand large and complex circuitry.

One of the ballistic-missile computers offers a good example of this approach. The equations, including those covering the effects of the earth's oblateness and of atmospheric reentry, involved transcendental func-

Table I: Vehicle-Computer Combinations

Aircraft

NAA B-70 bomber will use two general-purpose digital computers made by IBM.

Grumman A2F-1 Intruder uses a Litton digital computer for attack and navigation computations.

Grumman W2F-1 Hawkeye uses a hybrid GP-DDA computer-detector made by GE-LMED to process radar information for a second digital computer made by Litton.

NAA A3J attack bomber uses Autonetics' Verdan combined GP-DDA computer.

Convair F-106 interceptor uses Hughes' general-purpose "Digitair" computer.

Aircraft that carry the *APQ-81 track-while-scan radar* use Westinghouse Air Arm's WDP-167, which the company calls "the fastest military computer in operation." (It is capable of 166,666 addition operations per second.)

Drones

Fairchild USD-5 uses Hughes' HCM-120, a modified general-purpose computer.

Republic USD uses the MSD-223, special-purpose built by Republic.

Missiles

Boeing Minuteman ICBM will use a general-purpose computer designed by Autonetics.

Convair Atlas ICBM in its advanced version uses a 200-lb general-purpose computer built by Arma. Later Atlas missiles will use a 15-lb microminiature version of this computer.

Douglas Skybolt ALBM uses a DDA designed by GE-LMED.

Martin TiVan II ICBM uses a 90-lb general-purpose digital computer made by IBM.

Lockheed Polaris IRBM uses a special-purpose DDA designed by GE-LMED.

NAA Hound Dog air-to-surface missile uses Autonetics' Verdan.

Spacecraft

Centaur launcher will use a general-purpose computer designed by Librascope.

Saturn launcher will use a digital computer that reportedly will be an off-the-shelf production unit.

Dyna-Soar manned boost-glider will use a digital computer.

tions of seven variables and hundreds of geophysical and system constants. By clever analysis, the project mathematicians came up with approximations and numerical methods that made it possible to solve these guidance equations with fewer than 30 multiplications and with no divisions, no square roots, and no trigonometric or inverse trigonometric operations. Also less than 30 constants have to be stored. The designers of the computer report that, despite all the short-cuts they took, they got a guidance precision better than what's needed for the ICBM range.

As *Table II* shows, many airborne digital computers combine general-purpose and digital-differential-analyser (DDA) designs. The purpose in building these hybrid machines is to take advantage of the best points of each type: the flexibility of GP computer, which can handle a variety of problems, and the high iteration rates of the DDA.

Unlike the GP computer, which arrives at a complete solution with each computation cycle, the DDA continuously calculates the incremental corrections to a previously derived solution. It considers the initial conditions and, using a closed-loop cycle, continuously adds changes to the solution instead of starting the problem all over again (as a GP machine would do). If the iteration rate of a DDA is high enough, the solution in effect is continuous.

Many computer designers are taking a close look at magnetic logic elements. For one thing, these elements have about 10,000 times more radiation resistance than do semi-conductors and diodes, it's been calculated. Experimental computers built with magnetic elements are also extremely reliable and cheap.

These advantages, however, are offset to some extent by the low operating speed and high power drain of magnetic elements. Three elements under consideration for magnetic switching—the parametron, the laddic, and the transfluxor—all operate well below a megacycle. In addition, their power dissipation is directly related to operating speed.

The answer to the problems of all-magnetic computation may lie in square-loop magnetic films of Permalloy. These have the advantages of high packing density, resistance to high temperatures (up to 200 deg C) and other rough environments, and millimicrosecond speed. Much progress, though, remains to be made on this type of logic before it is ready for production computers.

The thin-film cryotron is another promising logic and memory device, although its use in airborne computers may still be rather far off. Its advantages are millimicrosecond switching time, low cost, and very small size—some 10,000 cryotrons can be packed into a cubic foot. Their big drawback, of course, lies in the need for cryogenic cooling equipment. However, this problem may be minimized by the development of miniature, closed-cycle cryogenic computers (i. e., computers with cryogenic memories and logic), all of whose components would work in a controlled environment.

At least two types of storage

All the airborne digital computers covered by SPACE/AERONAUTICS' survey have at least two separate types of storage: a permanent, or long-term, storage and a ready-access storage for the problem being worked on. A large capacity memory in the form of a miniature magnetic drum is normally used for long-term storage of instructions, constants, and tabular data. In some computers, long-term information is directly wired into magnetic cores for permanent storage. A trend seems to be in the offing to use multi-aperture cores for long-term storage where rapid access is needed.

For the most part, random-access memories of ferrite cores are used for the storage of variables. The

table II: airborne digital computers

	DESIGNATION & TYPE	SIZE & WEIGHT	POWER REQUIREMENT	LOGIC SWITCHING ELEMENTS	STORAGE		WORD LENGTH
					TYPE	CAPACITY	
American Bosch Arma Corp., Garden City, N. Y.	Flexible Computer; GP	2.5 cu ft, 75 lb	100 W	transistors	multi-aperture ferrite cores,	2048 words	28 bits & 4 guard bits
	Micro-miniature Flexible Computer; GP	0.3 cu ft, 15 lb	50 W	transistors	multi-aperture ferrite cores	2304 words	22 bits & 5 guard bits
Autonetics Div. North American Aviation, Inc., Downey, Calif.	Verdan; serial GP & serial DDA	1.4 cu ft, 82 lb	370 W	diodes	6000-rpm magnetic disk	1664 words in 13 channels (5 channels used by incremental section; all words addressable by GP instructions; data for GP occupy 1024 words)	26 bits (incl. sign spare & synch bit)
Ford Instrument Co., Long Island City, N. Y.	Fordac; fliable breadboard model of incremental digital computer		170 W	transistors, diodes	core registers	405 bits	
General Electric Co., Light Military Electronics Dept., Utica, N. Y.	CVI-27; digital, conditional variable increment, stored program	~1 cu ft[1], ~40 lb	490 W	magnetic cores, diodes (other elements can be used)	magnetic drum	40,000-70,000 bits	19 bits
	Skybolt Missile Guidance Computer; DDA			transistors, diodes	magnetic core register		
	Polaris Missile Guidance Computer; special-purpose DDA	25-25 lb[2]		transistors, diodes	magnetic core shift registers; semi-conductors		
	WZF-1 Computer-Detector; GP & DDA			transistors, diodes	magnetic drum		
	Gevic; digital, variable increment	0.8 cu ft, 45 lb	490 W	magnetic cores, diodes	magnetic drum (main memory); rapid-access memory		2[19]

NOTES: (1) Exact size depends on application. (2) Unofficial figure.

cores may be supplemented by sonic or ultrasonic delay lines.

Magnetic drums are used in most computers for high-capacity, long-term storage. The capacities of current airborne drums range from 60,000 to 300,000 bits. This type of storage has the advantage of non-volatility, non-destructive readout, and low bit cost in terms of weight, volume, and power drain. A weak point is that access to information in the drum is a serial process and therefore slow. Parallel methods can be used in exchange for capacity, however. Another drawback is that the drum rotates, so that you have lubrication and bearing problems. In spacecraft, furthermore, the angular moments produced by the drum's rotation cannot be neglected and must be counterbalanced. This leads to stabilization and flight-control problems, which can, however, be avoided by going to static memories. The more advanced drums use air-floated read-write heads, and a recent Sperry Gyroscope design uses air bearings as well.

Conventional toroid, single-aperture *magnetic-core* matrices are normally used for random access 1000-2000-bit storage. The core family also includes ferrite sheets containing a number of holes, each of which does the job of a single toroid; twistors; thin films; and multi-aperture cores, like the transfluxor and biax elements.

Cores have the great advantage of quick access. The time for single-aperture devices is one micro-second, multi-aperture elements have access times of 0.2-0.4 usec, and thin films have access times in the 0.1-usec range.

Conventional cores have a destructive readout—when the stored information is sensed, it is erased from the core. Some designers get around this in permanent memories by wiring the data into the core. Then, to retain the random access, another core matrix is used for readily available data. Multi-aperture cores have non-destructive readout as well as a wider temperature range than the single-aperture devices.

Many designers believe that the magnetic film is the ultimate in solid-state random-access storage. These films are made of Permalloy and have 0.1-usec switching speeds and a wide temperature range. High-speed, high-current driving circuits have yet to be developed to match the speed of the films, however.

Quartz and magnetostrictive *delay lines* are being used in several computers for short-term "scratch-pad" memory. They have the fewest components per bit of all memory systems. GE LMED has developed a sonic delay line that takes up 20 cu in and weighs 20 lb, yet has a 60,000-bit capacity. Its power dissipation is 20 W.

A *solid-state memory* using one-inch cubes of silicon wafers with etched and vacuum-deposited components is under development at Librascope for a spacecraft computer. Its storage capacity is 70,000 bits per cubic inch.

Tunnel diodes look promising as memory elements because of their simplicity, small size, low power drain and, above all, their millimicrosecond switching times. Presently available tunnel diodes provide read-write cycle times of 0.1-usec. In the near future, diodes are expected to lower this value to 0.01-usec.

Cryotrons also offer millimicrosecond switching times. The same good and bad points apply for their use as a memory element as for their use as a logic device.

Catalog memories compare a word with every other stored word in a single operation. Westinghouse Air Arm is studying this type of memory using both cores and tunnel-diode elements. In the tunnel-diode design, all bits of a given word are compared in a single, parallel operation with all the words in the memory; in the core designs, the comparison is a bit-by-bit, sequential operation.

NUMBER SYSTEM	NUMBER RANGE (SCALING)	CLOCK SPEED	SPECIAL FEATURES	FUNCTIONS
binary, 2s complement for negative numbers	fixed point fractional	250 kc	packaged for ICBM	guidance & navigation
binary 2s complement for negative numbers	fixed point fractional	1 mc	packaged for ICBM	guidance & navigation
binary, 2s complement for negative numbers	-1 to $+1$, -2^{-23} to $+2^{23}$	333 kc		in intertial system of the Hound Dog, Verdan commits to its memory any course of carrier B-52; afer launch, it calculates missile position & compares it with programmed course, gives range, steering and other control signals to missile flight control system—in Vigilante nav-bomb system, Verdan determines actual position of aircraft by performing calculations on autonavigator outputs
binary	fixed point binary, number less than one		high solution rate permits on-line operation; non-real time solution using tape input; error-checking	strapped-down inertial navigation system in which stable platform is replaced by high-speed solution of coordinate system transformation matrix
	variable; changed automatically by problem rates, any integral power of 2 from 0 through 13 (1-8192)	150 kc	self adaptive magnitude of increment is automatically adjusted by speed at which problem is changing	weapon delivery, navigation, flight control, fuel management displays, air data
				ballistic computations
				missile guidance (Pitch & Yaw) certain discrete commands
				quantitizes real-time radar data & transforms them into target location & height
	variable, changed automatically by problem rates 1-0, ±1, ±4, ±32	150 kc	selects increment according to speed at which problem is changing (self-adaptive)	central station computer for all system functions

	DESIGNATION & TYPE	SIZE & WEIGHT	POWER REQUIREMENT	LOGIC SWITCHING ELEMENTS	STORAGE		WORD LENGTH
					TYPE	CAPACITY	
Hughes Aircraft Co., Aerospace Engineering Div., Culver City, Calif.	MA-1 Digitair; system-oriented, serial, GP	6.5 cu ft, 300 lb (overall); 3.2 cu ft, 122 lb (central computer)	1.7 kw	subminiature tubes	4800-rpm magneic drum capacity	13,320 orders & numbers (~300,000 bits total)	19 bits (16 bits + sign & 2 spaces)
	HCM-100; system-oriented, serial, GP	5.1 cu ft, 182 lb (overall); 3.3 cu ft, 114 lb (central computer)	1.0 kw	solid-state (Ge)	2340-rpm magnetic rum	4200 orers & numbers (900,000 bits total)	21 bits (18 bits + sign & 2 spaces)
	HCM-120; system-oriented, serial, GP	2.3 cu ft, 85 lb	370 W	solid-state	magnetic drum	5280 orders or 2640 numbers (55,000 bits total)	22 bits (19 bits + sign & 2 spaces)
	HCM-200; system-oriented, parallel, GP	1.9 cu ft, 125 lb	365 W	solid-state	magnetic core (random access), magnetic drum	core: 512 words, 12,288 bits (expandable in blocks of 5.2 words to 4096); drum: 45,000 orders & numbers	24 bits (23 bits + sign)
	HCM-201; system oriented, GP	<1 cu ft, 5.5 lb	40 W	solid-state	magnetic core (random access)	1024 orders or 512 numbers; 12,288 bits (expandable in blocks of 1024 up to 4096) 16	24 bits (23 bits + sign)
	HCM-302; DDA	<1 cu ft	30 W	solid-state (Si)	constants & program wired variables: magnetic core shift register	words for variables	17 bits (16 bits + sign)
Librascope Div., General Precision Inc., Glendale, Calif.	ASN-24; digital, dual-address, serial, stored program, operates in conjunction with an input-output unit & display units in manned aircraft	0.3 cu ft (swept volume), 37 lb	120 W	transistors, diodes, relays	magnetic drum	2560 words	25 bits
	Centaur Guidance Computer; digital, dual-address, serial, stored-program GP with input output unit	0.83 cu ft (swept volume), 62.5 lb	190 W AC, 25 W DC	transistors, diodes, relays	magnetic drum	64,000 bits	
	CP-209; incremental	3 cu ft, 133 lbs	1.76 kw		magnetic drum	2550 words	14 bits (single & double length)
	L-407; GP	1 cu ft 60 lb (incl. input & output)	265 W	transistors, diodes	6000-rpm magnetic drum	1920 words (1792 words permanent, 128 words temporary)	22 bits single & double length
Litton Systems Inc., Beverly Hills, Calif.	LC-400; real-time GP	6 cu ft, 257 lb	600 W	transistor	magnetic drum & magnetic cores	drum: 10,952 words cores: 128 words 30,000 words	21 bits
	LC-300; special-purpose	1.85 cu ft, 50 lb	150 W	transistors	magnetic drum	drum: 15,360 words	18 bits
	LC-7000; GP, high-speed data processing & control	6 cu ft buffers, (5 cu ft without input output buffers); 330 lb	1 kw	transistors	magnetic drum & magnetic cores	cores: 1280 words	22 bits
	LC-600; real-time GP	6.26 cu ft, 280 lb	1.1 kw	transistor	magnetic drum, magnetic cores	drum: 17,000 words; cores: 128 words	20 bits
	LE-500; special-purpose	2.3 cu ft, 95 lb	250 W	transistors	magnetic drum	640 variable purpose computing elements	variable
	LC-800; DDA & dual-address, real-time GP	3 cu ft, 160 lb (with input-output)	450 W	transistors	magnetic drum, magnetic cores	12,800 words	24 bits
	LE-200; special-purpose incremental, real-time DDA	0.625 cu ft, 39 lb	70 W	transistors	magnetic drum	150 variable-length words	variable
McDonnell Electronic Equipment Div., McDonnell Aircraft Corp., St. Louis, Mo.	DIGACC; serial digital	0.32 cu ft, 26 lb (incl. input-output & power supply)	24 W		magnetic cores for permanent & temporary storage	permanent: 1-8 modules of 256 words each; temporary: 64 words	16 bits
Motorola, Inc., Military Electronics Div., Scottsdale, Ariz.	digital	0.88 cu ft, 42 lb	75 W	diode resistor logic with transistors in active elements	magnetic drum	2048 words	21 bits
Republic Aviation Corp., Farmingdale, N. Y.	MSD-223; real-time CP	1.1 cu ft, 59 lb	375 lb	transistors, diodes	magnetic drum	70,000 bits	23 bits
Westinghouse Electric Corp. Air Arm Div., Baltimore, Md.	WDP-167; digital, parallel, synchronous	6.5 cu ft, 285 lb	800 W	transistors, diodes	magnetic cores	2700 words	20 bits
	WDP-400; digital, parallel, synchronous	5 cu ft, 200 lb	800 W	transistors, diodes	magnetic cores	2048-8192 words in random-access memory (increment 512 words), 2048-4096 words in multi-operture instruction memory (increment 512 words)	24 bits

ADDENDA—Data on the following computers arrived too late for inclusion in the table:

Arma Atlas ICBM Computer—Design begun in 1955. 8 cu ft, 200 lb. Logic elements are transistors. Diode matrices used for storage of constants; quartz delay lines for working storage.

Autonetics Minuteman ICBM Computer—Serial GP all-transistor computer. Approximately 2 cu ft. Transistor logic. Storage by rotating, air-baering-type magnetic-disk memory, 80,000 bit capacity. 27 bits word length. Binary number system. Serial operating mode. Generates stabilization, steering staging, and thrust cutoff signals. Solves guidance and flight control equations. Supplies pre-arm signals to re-entry vehicle, flight command signals to yaw, pitch, and roll nozzle control units, automatically calibrates and aligns missile guidance at periodic intervals during ready life in silo. Settings of guidance gyros and velocity meters periodically checked by program stored in computer's memory. If errors are detected computer automatically intakes corrections.

Burroughs Airborne Digital Computer—Central computer for fire control and navigation. 3 cu ft 190 lb. Logic switching elements are replaceable high-density "logi-mods" averaging 19 electronic components each encapsulated in ¼ cu in. Storage by 3-in-diameter magnetic drum. 215,000 bit capacity. 1.33 uscc clock speed. Cores used for random-access memory. Central computer for fire control and navigation.

IBM Titan II ICBM Computer—A serial binary programmable type using a magnetic 6 drum for constant and working data storage. Drum capacity is 100,000 bits. 82 magnetic read-write heads. 90 lbs.

Ramo-Wooldridge RW-30—Completely transistorized (silicon). 203 lb, 4.19 cu ft. For high-performance military aircraft.

IBM Main Digital Computer for NAA B-70 Bomb-Nav System—GP central computer with high speed input-output processor. Modes of operation are parallel arithmetic, serial-parallel program, serial input-outut. Conventional binary is used for the number system along with fixed-point arithmetic nota-

NUMBER SYSTEM	NUMBER RANGE (SCALING)	CLOCK SPEED	SPECIAL FEATURES	FUNCTIONS
binary	$-1 < x < 1$	182.4 kc		automatic navigation; dead-reckoning; compatible with all Sage control modes & data links; tie-in with aircraft controls; speed-attitude profiles
				optimizing interceptor fuel & tactics; diagnostic and functional self tests of computer
binary	$-1 \leq x < 1$	250 kc		functional tests of radar comm & air data systems determines optimum attack steering
				autonavigation using inputs from Doppler-inertial nav systems, manually selected points, and/or data link; compatible with all Sage control modes & GPA controls; computation of target range in heavy ECM; airborne self-checking of computer, IR, inertial & radar subsystems; attack guidance; displays of tactical situations
binary	$-1 \leq x < 1$	250 kc		
binary	$-1 < x < 1$	252 kc	welded modules; random-access memory expandable without additional electronics	preflight alignment & drift trim of stable platform; Schuler tuning; nav & flight control; section of alternate flight control; selection of alternate flight profile segments as directed by data link; coordinated conversion
				preflight alignment & drift trim of stable platform; self-check of computer & systems; target evaluation & attack control; nav control; preflight checkout of total system; continuous monitoring of all vehicle subsystems
binary	$-1 < x < 1$	500 kc		
				preflight alignment & drift trim of stable platform system; readiness pre-launch check; nav & steering; generation of cutoff & staging commands; self-check of computer & system
binary	$-1 < x < 1$	71.4 kc	no special cooling required; fully repairable	processes data from inertial platform & accelerometers, provides steering signal output; solves guidance equations & routines 700 times per sec; determines power cut off point
		160 kc		guidance & navy computations
				inertial guidance computer for position-keeping, steering, engine control
		238 kc	retraceable sine-cosine & exact multiplication generations (35,000 mult. per sec; 17,000 sine & cosines per sec)	bomb-nav
		144 kc	ruggedized & transistorized; high-speed pulse accumulation; 535 mult. per sec; 9600 add per sec; multiple control; mechanized square root	missile control
		266 kc	unusual logic design; 4 address instructions; high fidelity high reliability	nav & flight control
		117.3 kc		control
		500 kc (arithmetic), 250 kc (drum)	av. instruction execution rate of 125,000 add operations per sec	bomb-nav; missile control; weapon control
		200 kc	very flexible large input-output capacity, advanced packaging	nav, weapon delivery, cruise control, control of output & situation displays
binary		250 kc		nav & flight control
		425 kc	manned & unmanned high-performance vehicles	flight control; display nav
		160 kc	programing flexibility	central computer
binary	fixed point, fractional	500 kc	long-time reliability, low power consumption, no moving parts, modular construction, high bit rate, small number of components	guidance control
binary, 2s complement	$-1 \leq 0 < 1$	~260 kc	quick-access loops, relatively fast 2-bit multiplier	
binary	fixed point	309 kc	minimum-access programing, modified 2-address instructions with 2 commands, disk modules using off-the-shelf components	inertial nav, guidance control, data processing, platform alignment
binary	+1 to −1	1 mc	167,000 instructions per sec (incl. instruction & oper and memory cycles)	central control for AN/APQ-81 radar, performs multi-target track-while-scan correction (16 targets)
binary	+1 to −1	2 mc	electrically alterable memory, 400,000 operations per sec, flexible, large capacity based on proven hardware & advanced techniques	

tion. Word length is 22 bits plus sign and parity. Clock rate is 166.4 kc. Single address is used. Storage by magnetic drum (26,624 instructions and 6656 tabular constants) and by magnetic cores (1024 words). 24 usec for addition and subtraction, 264 usec for multiplication. 288 usec for division.

IBM Emergency Computer for B-70 Bomb-Nav System—GP central computer with high-speed input-output processor. Serial mode of operation. Binary number system. Fixed-point arithmetic notation. Word length is 23 bits plus sign and parity. 166.54 clock rate. One-plus-one address. Storage my magnetic drum (3456 instructions and constants and 384 words of data). 624 usec for addition and subtraction, 3744 usec for multiplication, 3744 usec for division.

Sperry Automatic Mode Selector—Decision-making element of ALQ-27 ECM system (slated for B-52 but cancelled). GP type. Transistor and core logic. Binary number system. 206.5 kc clock rate. 3.31 cu ft, 91 lb. Performs self-checks and generates timing signals for use in the overall system.

Sperry Translock—Miniature transistorized GP computer. 0.2 cu ft, 13 lb. Logic switching by silicon transistors and diodes. Storage by non-destructive core memory with capacity for program of 4096 17-bit words and 256 21-bit words of data. Binary number system and 250 kc clock rate. Intended for celestial and inertial computations for aircraft and missiles.

Sperry Abbacus (advanced building block airborne computer system)—Arithmetic computer. 2.4 cu ft, 63 lb. High-speed silicon transistor logic and magnetic-drum memory. 10,592 22-bit words storage capacity (8192 words for instruction, 2048 words for constants, 352 words for variable data). 282 kc clock rate. For computation in strategic and tactical bomb-nav, weather recon, missile fire control, and missile guidance systems.

Sylvania Airborne Digital Computer—2 cu. ft. 6000 transistors. IMC clock rate. 4 usec memory cycle time. Memory is linear selection ferrite core. 240 words capacity.

Tunnel diode logic

looks good for spaceborne computers

by **James Hammill,** Development Engineer, Armament & Control Section, Light Military Electronics Dept., General Electric Co.*

Spacecraft electronics—particularly computers—require unusually high reliability, minimum volume, and low energy consumption. In computers, high reliability can be had by using inherently reliable circuits to perform operations in triplicate, with a "voting" process to accept the majority of answers. Increasing the number of parallel computing paths and improving reliability through redundancy should not, however, add too much to size, weight, or power drain.

Tunnel diodes are remarkably well suited to such requirements. They are inherently reliable, and a special tunnel diode computer circuit is available to provide the feature of majority logic, or voting. Also, the small size, negligible weight, and low voltage and current requirements of tunnel diodes let you add duplicate circuits in a trade-off for reliability.

The binary tunnel-diode logic circuits start with a three-phase clock that synchronously drives storage and decision logic stages. The basic building block for the logic is an "affirm" circuit that, depending on input terminals and biasing, can function as a shift-register, a majority logic, or voter, stage, an "and" stage, or an "or" stage. A tunnel-diode "not" module is also available as an inverter, or "not" stage.

DIGITAL COMPUTERS for spacecraft must be reliable and have minimum volume and weight, yet they must also operate on the lowest possible power input. For several reasons, tunnel diodes are well suited to such requirements:

- They have inherent high reliability and good stability of characteristics with temperature, and their radiation resistance exceeds that of other semiconductor devices.
- A special type of tunnel-diode multiple-input logic —the "voter", or majority, logic circuit—has been developed that gives a correct logic output if the majority of the inputs is correct. For example, a three-input circuit provides the proper output if either all three inputs or any two of the three are correct.
- The tiny size, ultra-low weight, and unusually low power requirements of tunnel diodes make it possible to use these majority circuits to perform logic functions in triplicate (or higher odd multiples). This substantially raises the computer reliability through circuit redundancy (see *Box*).

A significant factor in favor of tunnel diodes for space computers is their low voltage and current requirements in comparison with the competing devices for the "micropower" business: transistors, magnetics, and cryogenic devices. The maximum voltage needed for a germanium tunnel diode is 0.5 V, and that for a gallium arsenide type is less than 1.5 V. The maximum power for a one-milliampere germanium type is 0.5 mw.

Minimum module volume is limited

The minimum volume of microminiaturized modules is limited by the basic relationship between heat and size. In solidly packed electronic circuits component density cannot be increased so much that internal components can no longer be cooled. Minimum power requirements therefore clearly affect the module size, and it's important that tunnel diodes are still "loafing" at a clock frequency of one megacycle.

The *Table* compares a potted transistor flip-flop in current airborne equipment and a tunnel-diode logic circuit. The clock frequency of the transistor circuit is 200 kc; that of the tunnel-diode circuit, one megacycle. The volume and power requirements for the

* Light Military Electronics Dept., General Electric Co., Schenectady 5, N. Y.

transistor module are the same for the module and the logic function, but for the tunnel diode, these requirements are five times higher for the function than for each module, because of the greater number of the diode circuits needed for the same function. Nevertheless, the tunnel diode performs the same function as the transistor with 90 per cent less power dissipation and 80 per cent less volume. We can see that, if transistor circuits are packaged as closely as heat rejection permits, the equivalent tunnel diode circuits operate at lower temperatures; or that tunnel diode circuits can be packed tighter for the same operating temperatures.

Several circuits are in use

Several circuits have been developed for computing with tunnel diodes. The "twin" circuit, which uses tunnel diodes in pairs, provides the majority logic, voting, circuit as the logical building block. Originally developed by E. Goto, it has been modified and improved by a number of groups, including GE-LMED.* Our contribution has been to develop a simplified three-phase clock-signal generator (needed for this type of circuit) and a new logical inverter, or "not" circuit. Following up this work we are developing tunnel diode logic for a spaceborne computer and working with manufacturers to get high-quality tunnel diodes in "microdot" or similar packages.

The "twin" tunnel-diode circuit is not affected by moderate changes in diode characteristics so long as the pair of diodes changes together. Also, stability of characteristics with temperature changes is good. For example, the peak current of germanium diodes changes less than 10 per cent between —55 and 100 deg C, while the forward voltage drop varies over the temperature range in a regular manner from 0.55 to 0.35 V. For successful application of tunnel diodes in logic circuits, the pairs for the "twin" must track—at peak current—within 2-3 per cent and the forward voltages must be uniform within 3-5 per cent. Today, these requirements can be met by preselection; in the future, better manufacturing process control may make selection unnecessary.

Goto circuit has three blocks

The building blocks necessary to perform binary logic with the Goto circuit include:

- a three-phase 500-kc clock supply (*Fig. 1*);
- a basic "affirm" module, which delivers outputs of the same polarity as the majority of the input signals (*Fig. 2*);
- a basic "not" module, which delivers an output of a polarity opposite to that of the majority of the input signals (*Fig. 3*).

These functional logic blocks can, in various combinations, perform all the necessary logic operations. In this type of logic, a binary 1 is a small positive voltage, while a binary 0 is a small negative voltage.

The three-phase clock generator sequentially switches the transistors on or off by a signal from the preceding transistor. The time delay of each delay line sets the switching interval between one transistor's switching and the next. The signal propagates around a closed loop, providing sustained relaxation oscillations. The voltages on the transformer secondaries are approximate square waves of 0.35 V amplitude. The largest

* E. Goto et al., "Esaki Diode High Speed Logical Circuits;" IRE Trans. Electronic Computers, EC-9, March '60.

Reliability Improvement through Redundancy

In a simple computation circuit, in which a computation is performed only once, any circuit failure produces a wrong answer (A). If the computation is performed in triplicate and the three answers are compared in a majority logic, or voter, circuit, the correct answer is still produced even if one of the channel inputs to the voter fails (B). Should the voter fail, the computation would be wrong despite the redundant channels. If you add redundant voters, you get the correct output even if both a single channel and a single voter fail (C).

The significant improvement in reliability is shown by a comparison of the failure-probability equations:

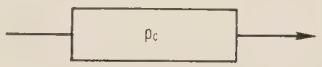
$$\text{simple} — p = p_c,$$

$$\text{one voter} — p = p_v + 3p^2_c + \ldots,$$

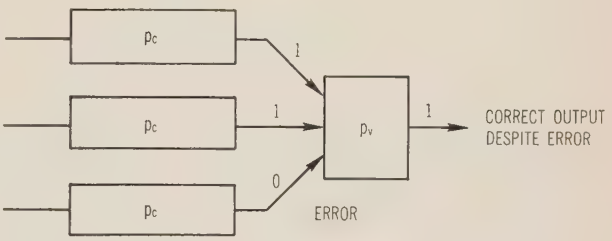
$$\text{three voters} — p = 3p^2_v — 2p^3_v + 18\, pp_vp_c^2 + \ldots,$$

where p is the total probability of failure; p_c, the probability of failure in a computation channel; and p_v, the probability of failure in a voter. For $p_c = 0.01$ and $p_v = 0.0001$, the actual values of p (in common multiples) are $10{,}000 \times 10^{-6}$ for the simple computation, 400×10^{-6} for one voter, and 0.21×10^{-6} for three voters.

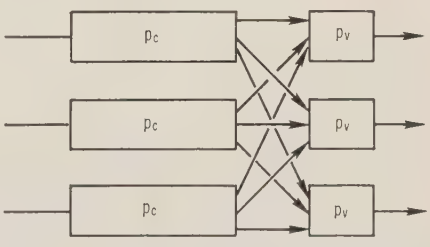
The reliability improvements will be highest when the reliability of individual devices, circuits, or channels is already good before you apply redundancy. If the initial reliability is poor, redundancy actually hurts rather than helps.



(A) SIMPLE COMPUTATION



(B) TRIPLY REDUNDANT COMPUTATION WITH MAJORITY VOTER



(C) TRIPLY REDUNDANT CIRCUIT WITH THREE VOTERS

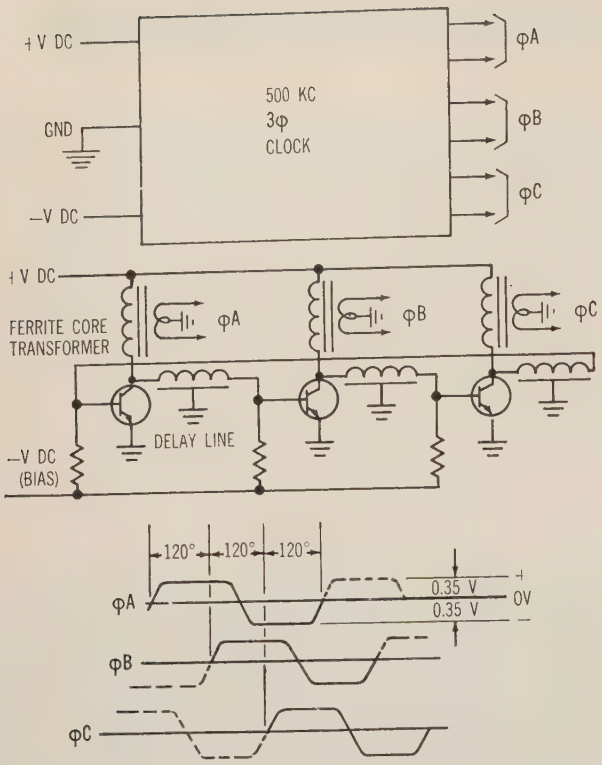


FIGURE 1: Block diagram, schematic, waveforms, and bread-board model of three-phase, 500-Kc computer clock supply developed by GE for tunnel-diode logic circuits described in text.

clock components are the transformers and delay lines.

The principal type of logic block in "twin" logic is the "affirm" module. These logic circuits operate by passing the contents of one stage to the next in time with the clock. Three modules, one for each phase, are needed for each bit of information in transit: one to receive the information, one to hold it, and one that rests.

The simplest logical connection of the "affirm" circuit is the shift register. Only one input and one output connection are used. Information is passed down the line synchronously with the clock.

When an odd number of inputs is used, the "affirm" circuit functions as a majority logic element. It responds to the majority of input signals, producing a like signal at the output. If one of the three inputs is permanently connected to a negative input (logical 0) then an output of 1 can occur only when two 1s are present in the input. The circuit thus functions as a two-input "and" element. If a permanent positive input is connected to one of the terminals, a 1-output results when a single 1 is applied to either or both signal inputs, and you have a two-input "or" logic function.

Input network sums the signals

The important feature of the "affirm" logic circuit is that it can accept several inputs (fan in) and deliver several outputs (fan out). The input network sums the various signals to produce a signal current (i_s) that is essentially the addition of all the signals. For example, if two inputs are positive and one is negative, the stage behaves as if it had but one positive signal.

In contrast to tubes and transistors, the tunnel diode is a two-terminal device in which the input and output are connected to the same terminals. By controlling the current through the diode, the voltage across can be varied (*Fig. 4*) between a low-voltage point (A) and a high voltage point (B). The minimum ratio of A to B is about 10.

A and B are located in stable regions of positive diode resistance; they are separated by an unstable negative-resistance region that produces the switching action used in logic circuits. In the "twin" logic circuits, the diode state is controlled by changing the input signal polarity.

Peak currents are closely matched

In *Figure 5*, for example, the tunnel diodes have closely matched peak currents. The clock supply voltage is obtained from the center-tapped transformer secondary. The tunnel diodes TD1 and TD2 are in series with the clock supply, and input and output voltages are taken with respect to the junction of the tunnel diodes and the grounded center tap of the transformer, which forms a bridge circuit between those points (X, Y).

Because of the low reverse voltage of tunnel diodes, X is approximately at ground potential when both diodes are conducting in the reverse direction, during that part of the cycle when the voltage at point W is positive with respect to Z. As the clock

Transistor and Tunnel Diode Logics

Logic Circuit Type	Volume (cu in.)		Power (mw)		Power per Unit Volume (mw/cu in.)
	Module	Function	Module	Function	
2-Transistor flip-flop	0.25		100		400
Tunnel diode majority logic ("twin")	0.01	0.05	2	10	200

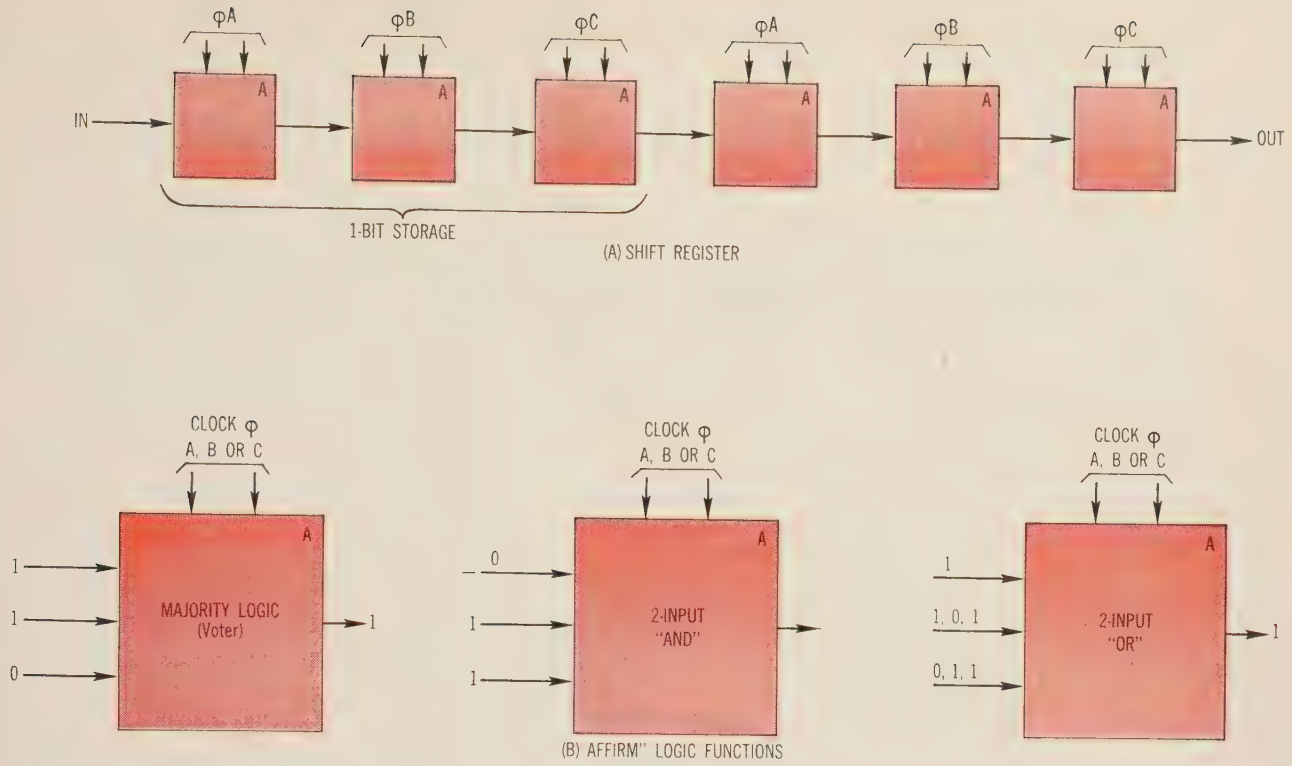


FIGURE 2: Logical building blocks and functions for "twin" tunnel-diode "affirm" logic.

supply voltage (e_c) goes positive, both diodes begin conducting in the forward direction. X remains at ground, however, until the current through one diode or the other exceeds its peak value. In which diode this happens first depends on whether the majority of the input signals is positive or negative with respect to ground.

If the sum of the inputs is positive, the signal current flows into X, subtracting from the current in TD1 and adding to the current in TD2. Therefore, TD2 reaches its peak current first and switches to the high-voltage state as at B in *Figure 4*. The supply voltage is purposely limited so that only one tunnel diode can be in the "high" state. The other diode (TD1) is forced to remain in the "low" state (as at A in *Figure 4*) for

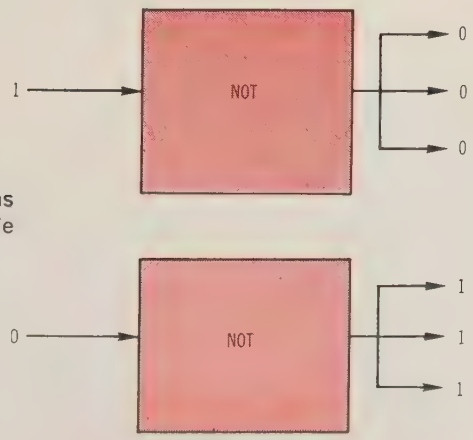


FIGURE 3: Logic functions of tunnel-diode "not" logic.

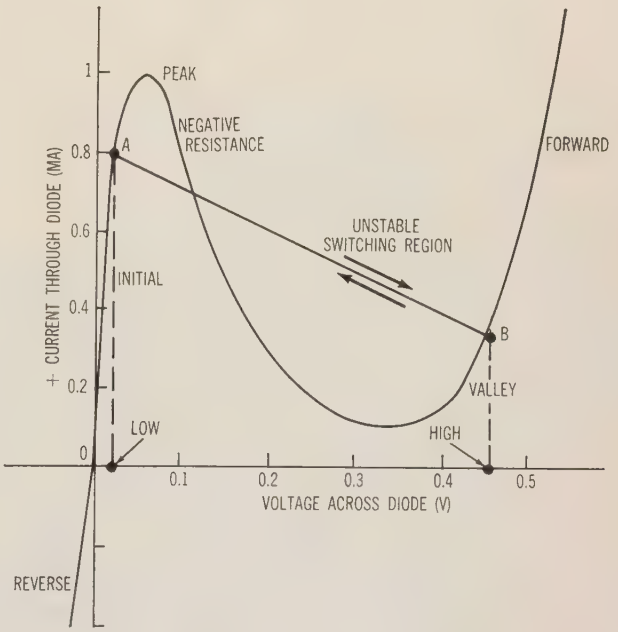


FIGURE 4: Germanium tunnel diode voltage-current characteristics show regions of operation for tunnel-diode computer circuit (switching) operation. The voltage across the diode is varied by increasing or decreasing the current through the diode. With the diode operating at point A, the increasing current above the peak value causes it to snap across the unstable region to B. The operating point is switched back to A by a corresponding change.

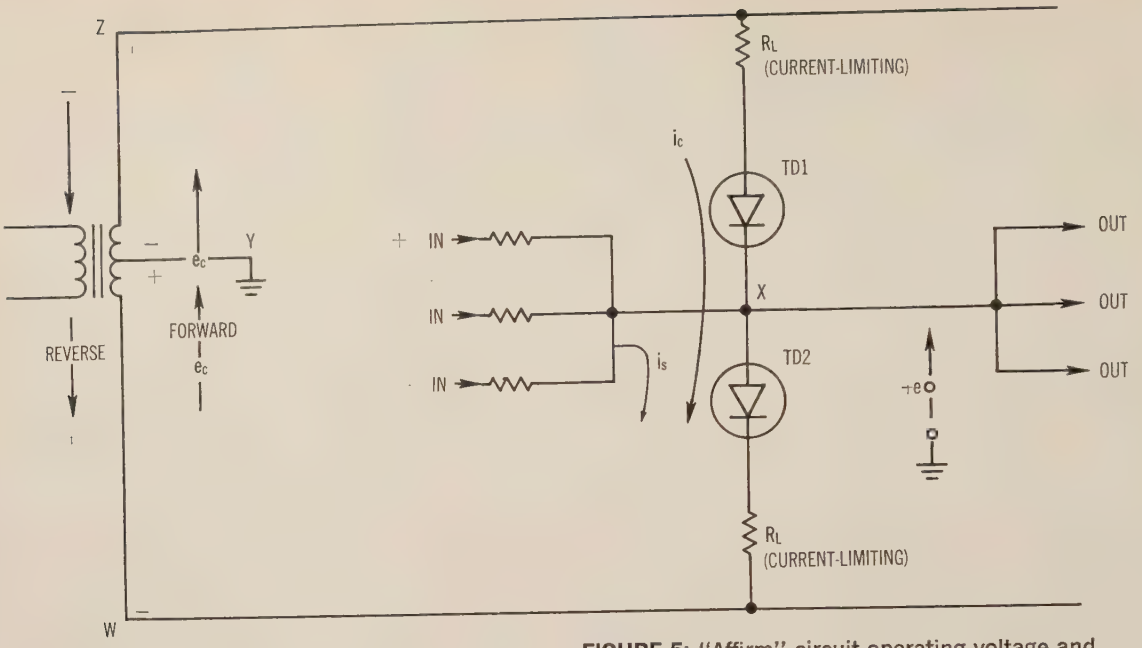


FIGURE 5: "Affirm" circuit operating voltage and current waveforms.

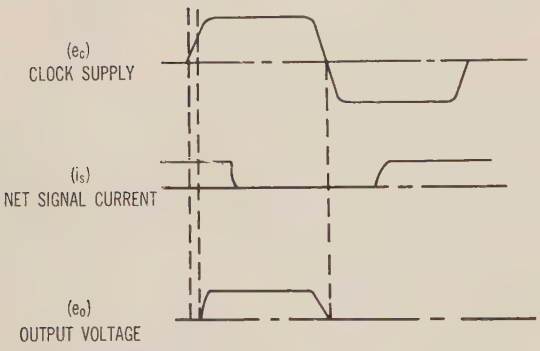
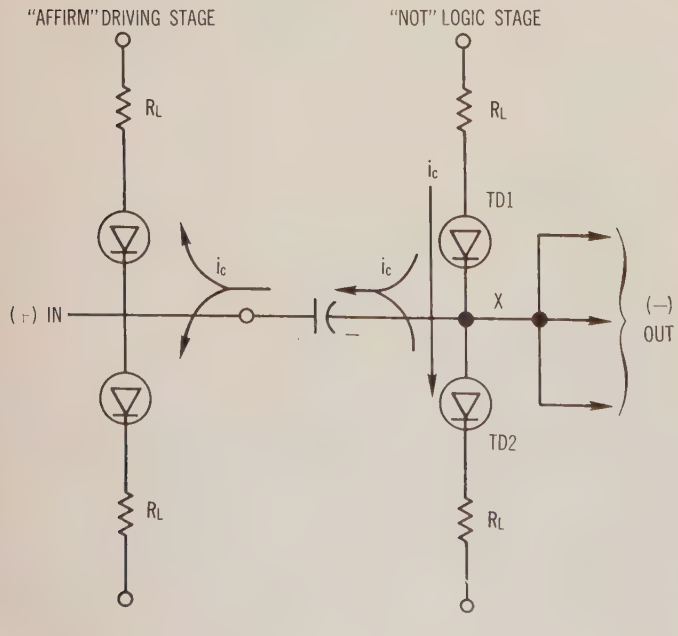


FIGURE 6: "Not"-logic-stage circuit driving stage and driving current relations. When the preceding stage is turned off, the capacitor discharge current drives TD1 or TD2 over the current peak to produce an output signal that is the reverse of the input.



the rest of the clock half-cycle. The output at X is then positive with respect to ground. If the majority of the input signals is negative, TD1 reaches the peak-point current first, and the output voltage at X is negative for the rest of the half-cycle.

In contrast to the "affirm" logic circuit, the "not" module produces an output opposite in polarity to the input. For example, an input 1 produces an output 0, while an input 0 produces an output 1. The actual "not" circuit is similar to the "affirm" circuit, but it has only one input, which feeds in through a capacitor (C) instead of through a resistor (*Fig. 6*). The current-limiting resistors are larger than those in the "affirm" circuit so that in the absence of a signal the clock voltage is too low to force either diode to its peak current.

At the beginning of the positive clock cycle, the signal current is zero, because the capacitor has been fully charged to the output voltage of the preceding stage. Therefore, although the clock voltage then rises to its maximum value, the voltage across the diodes remains in the region of the initial slope (A in *Figure 4*).

Signal current is zero at first

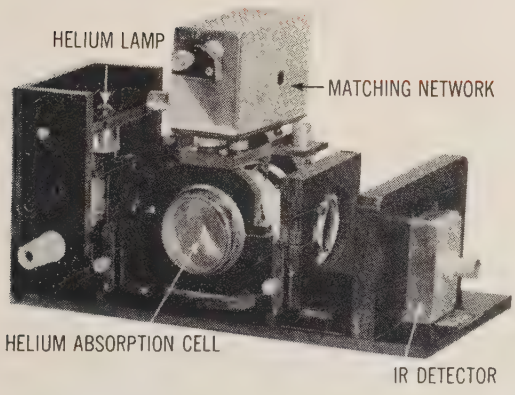
Inversion occurs when the preceding stage output falls to zero at the end of its clock cycle. C then discharges abruptly through TD1 and TD2 as in *Figure 6*. The capacitor discharge current (i_c) adds to the current in one diode, switching it over its peak and driving it into the forward state (B in *Figure 4*). The capacitor discharge current subtracts from the current in the other diode, reducing the current through it but causing no switching. So the final state of the diode pair is the unbalanced one as in the "affirm" logic, and an output voltage appears between X and ground, whose polarity is the reverse of the input's (*Fig. 6*).

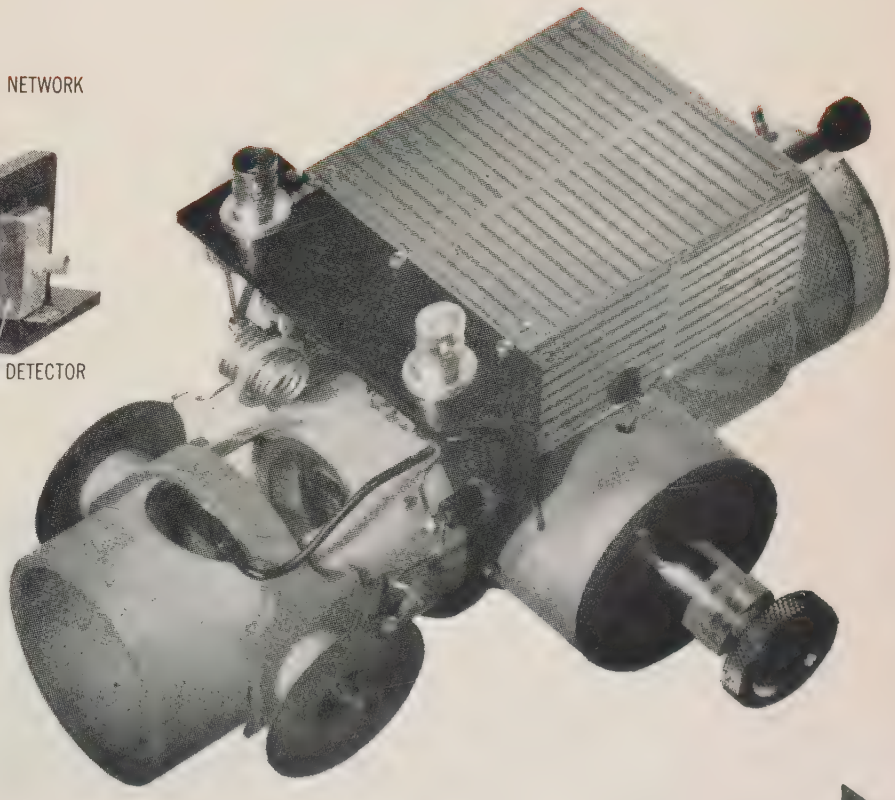
by **Bernard Kovit,** Associate Electronics Editor

Ultra-precise magnetometer

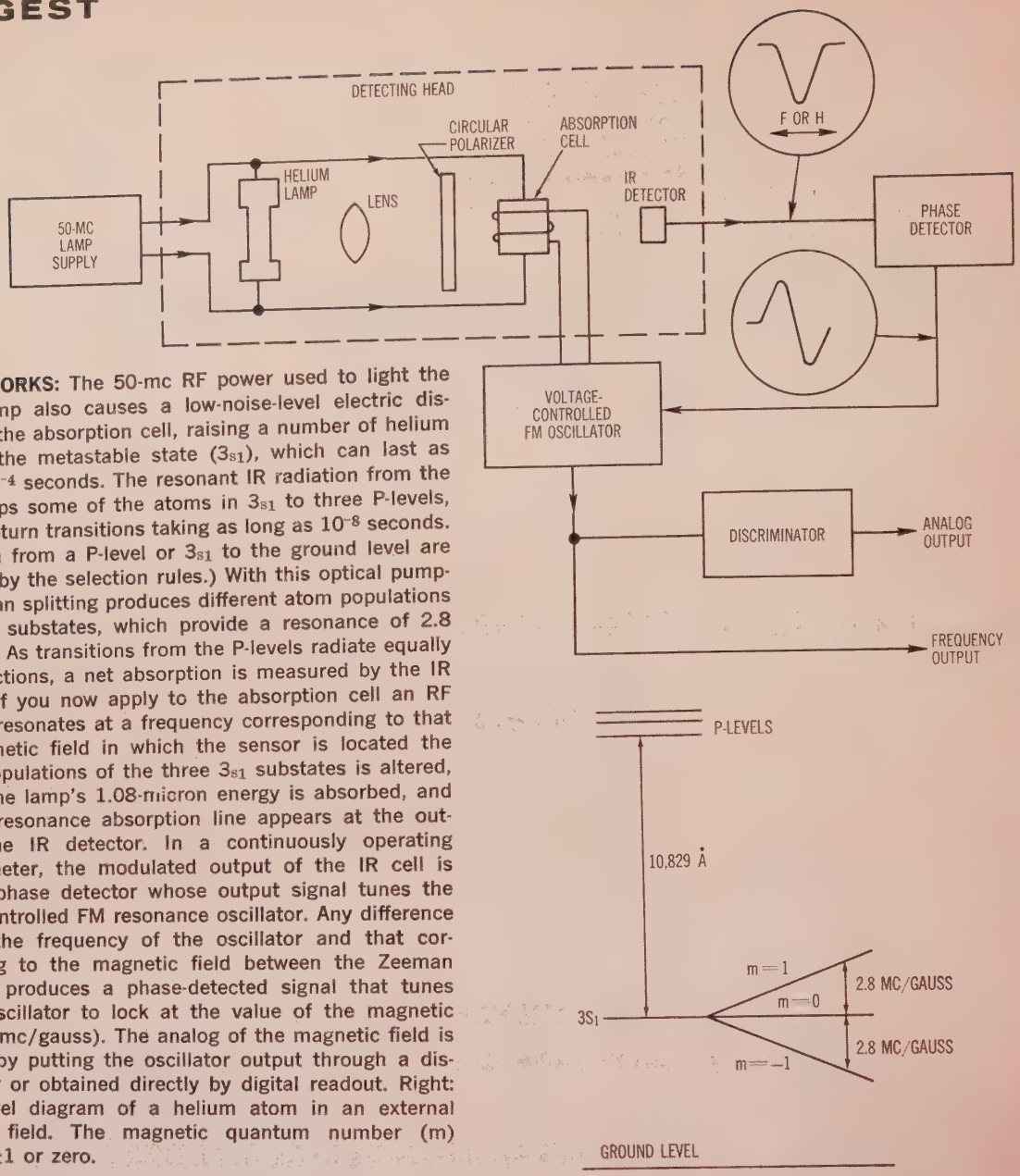
for undersea or space

A METASTABLE helium magnetometer developed by Texas Instruments, 6000 Lemmon Ave., Dallas 9, Texas, combines high sensitivity (one part in five million) with orientation independence ($<< 10^{-6}$ gamma/deg) and operation from near-liquid-helium temperatures to 200 deg C. An optically pumped resonance sensor, the detection head consists of a helium lamp, a lens, a circular polarizer, a helium absorption cell, and an IR detector. It measures a magnetic field by setting up a monitored light-flux-absorption process in a "dilute sea of metastable helium atoms" that is kept in a resonant RF field by a reference FM oscillator. This oscillator is tuned by the phase-detected signal from the IR detector used to monitor the absorption level. The presence of a magnetic field alters the absorption process and ultimately the frequency level of the reference oscillator, whose output can then be converted to an analog signal or a digital readout representing the value of the magnetic field. TI's magnetometer is well suited to probing magnetic fields in space or on the surface of the moon and could be used in airborne or underwater gear. Write in No. 67 on Reader Service Card for more information.

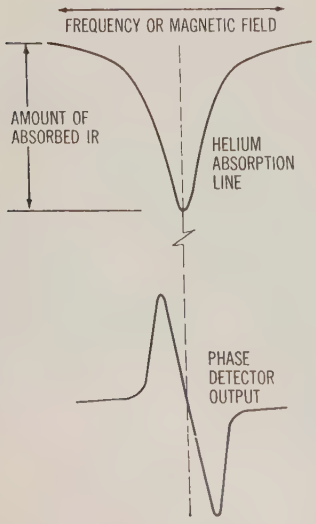




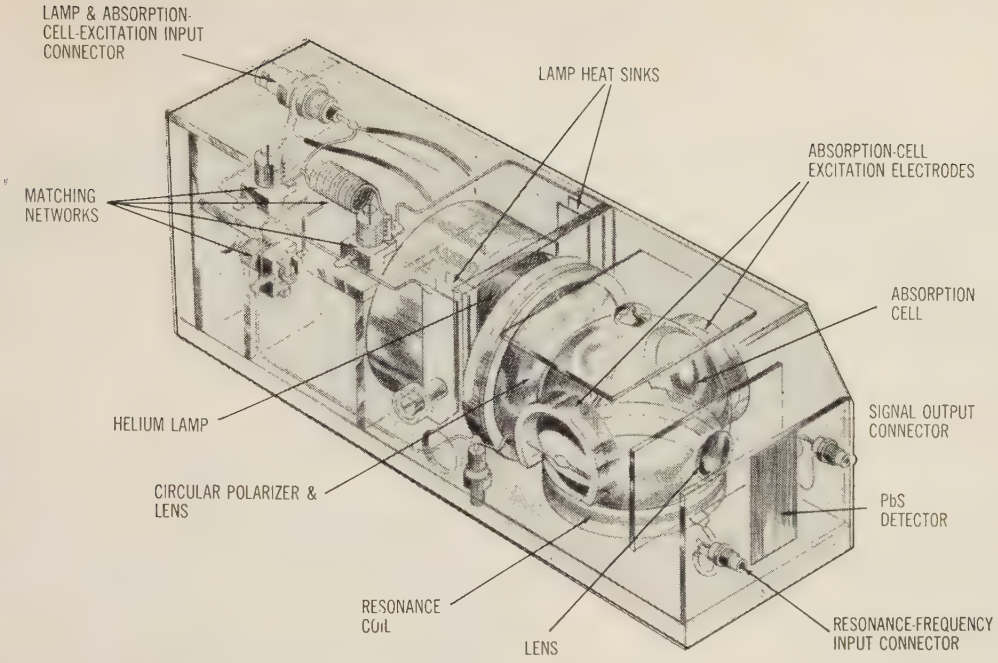
RUGGEDIZED sensing head of helium magnetometer (right). The matching networks and the IR detector are mounted in Faraday shields to reduce the effects of stray fields and eddy current noise. Above: Fixed-station helium magnetometer is 13 in. wide, seven inches high and deep and weighs six pounds.



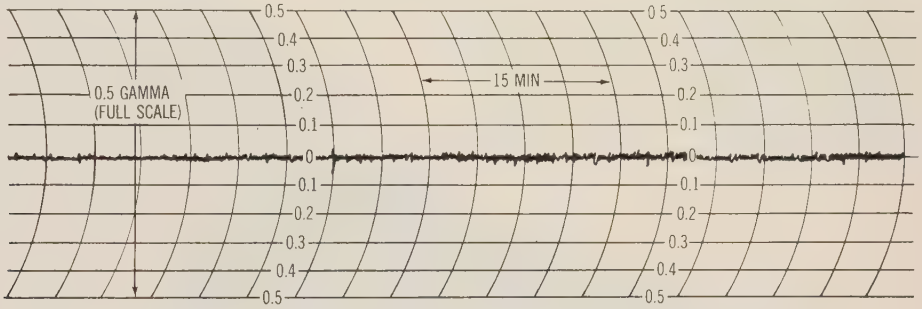
HOW IT WORKS: The 50-mc RF power used to light the helium lamp also causes a low-noise-level electric discharge in the absorption cell, raising a number of helium atoms to the metastable state ($3s_1$), which can last as long as 10^{-4} seconds. The resonant IR radiation from the lamp pumps some of the atoms in $3s_1$ to three P-levels, with the return transitions taking as long as 10^{-8} seconds. (Transition from a P-level or $3s_1$ to the ground level are forbidden by the selection rules.) With this optical pumping, Zeeman splitting produces different atom populations in the $3s_1$ substates, which provide a resonance of 2.8 mc/gauss. As transitions from the P-levels radiate equally in all directions, a net absorption is measured by the IR detector. If you now apply to the absorption cell an RF field that resonates at a frequency corresponding to that of a magnetic field in which the sensor is located the relative populations of the three $3s_1$ substates is altered, more of the lamp's 1.08-micron energy is absorbed, and a typical resonance absorption line appears at the output of the IR detector. In a continuously operating magnetometer, the modulated output of the IR cell is fed to a phase detector whose output signal tunes the voltage-controlled FM resonance oscillator. Any difference between the frequency of the oscillator and that corresponding to the magnetic field between the Zeeman substates produces a phase-detected signal that tunes the FM oscillator to lock at the value of the magnetic field (2.8 mc/gauss). The analog of the magnetic field is obtained by putting the oscillator output through a discriminator or obtained directly by digital readout. Right: Energy-level diagram of a helium atom in an external magnetic field. The magnetic quantum number (m) equals ±1 or zero.



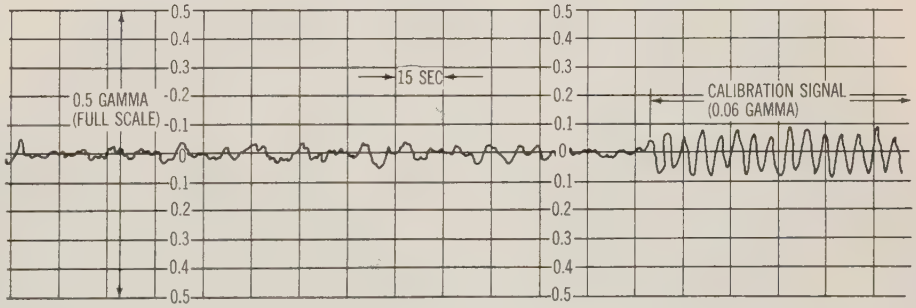
IR DETECTOR output (left) is produced by frequency-modulating the resonant RF field applied to the absorption cell so that it sweeps through the resonant frequency. Below: Coaxial version of the helium magnetometer is probably the world's smallest resonance sensor, says TI. Only 3½ in. long and 1½ in. wide, it is complete except for IR cells on the outside surface.

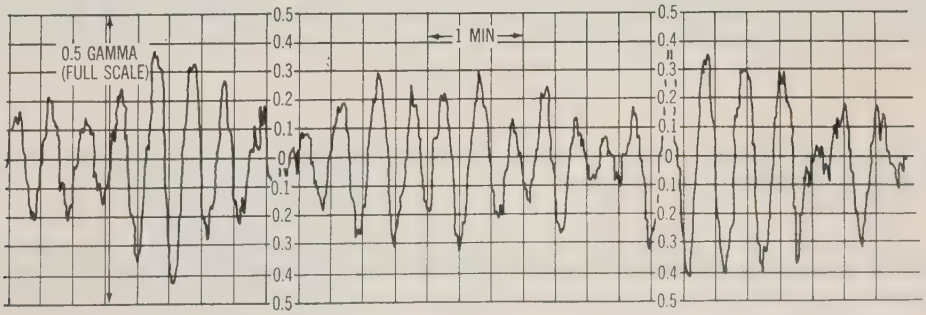


SIZE AND WEIGHT are extremely important in both space-borne and airborne magnetometers. This advanced unit weighs about two pounds measures 8x2x3 in. overall, including the RF matching networks used to couple the 50-mc power from a 50-ohm transmitter to both helium lamp and absorption cell.



FIELD MEASUREMENTS: "Quiet" geomagnetic activity with a total variation of only ±0.01 gamma (top), activity sensed with an 0.06-gamma test signal superimposed (center), and record showing some nearly periodically beating PC's geomagnetic activity (bottom). These data were obtained at TI's magnetics test range 20 miles northwest of Dallas. Each record was made with a single magnetometer.



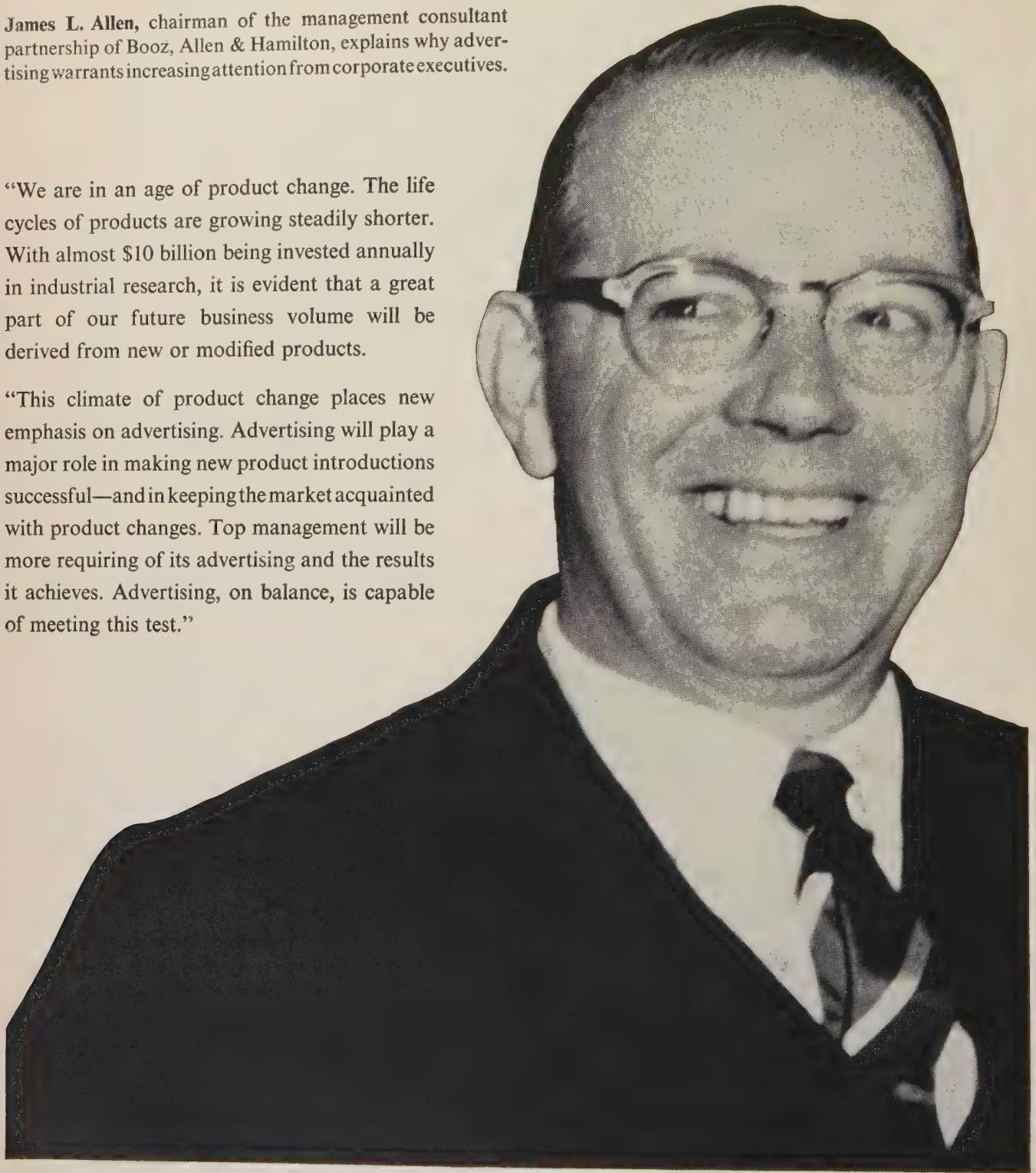


"More money for advertising! Why?"

James L. Allen, chairman of the management consultant partnership of Booz, Allen & Hamilton, explains why advertising warrants increasing attention from corporate executives.

"We are in an age of product change. The life cycles of products are growing steadily shorter. With almost $10 billion being invested annually in industrial research, it is evident that a great part of our future business volume will be derived from new or modified products.

"This climate of product change places new emphasis on advertising. Advertising will play a major role in making new product introductions successful—and in keeping the market acquainted with product changes. Top management will be more requiring of its advertising and the results it achieves. Advertising, on balance, is capable of meeting this test."



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Check Inquiry Form on Page 141➡

SCIENTISTS AND ENGINEERS:

Follow-On Atlas Programs Mean New, Long-Range Opportunities.

Now operational, the Atlas weapon system stands as a unique symbol of scientific, engineering and military achievement. The design, development and testing of this reliable missile was an undertaking of immense complexity.

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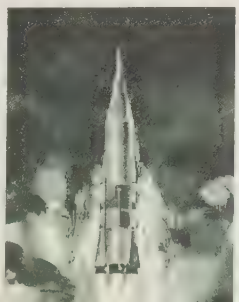
Atlas is the free world's first intercontinental ballistic missile; the first missile to travel more than 9,000 miles across the earth's surface; the only one to lift itself into orbit. Atlas marked the first use of swivel engines for directional control and it was the first to use airframe skins as fuel cells.

Many more "firsts" lie ahead for this reliable rocket. If you are the sort of inventive engineer or scientist who can contribute ideas and solutions to the problems surrounding the mastery of space, you and Convair/Astronautics have a common interest.

You'll find most of the details on this and the following page, plus a convenient inquiry card. If the card has been removed, or if you wish to furnish or request more detailed information, write to Mr. R. M. Smith, Industrial Relations Administrator-Engineering, Mail Zone 130-90, Convair/Astronautics, 5673 Kearny Villa Road, San Diego 12, Calif. (If you live in the New York area, please contact Mr. T. Cozine, manager of our New York Placement Office, 1 Rockefeller Plaza, CIrcle 5-5034.)

CONVAIR / ASTRONAUTICS



CONVAIR DIVISION OF GENERAL DYNAMICS

ENGINEERS AND SCIENTISTS

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MECHANICAL DESIGN: BSME or AE for pneumatics, hydraulics, and fluid systems design and test. Also missile GSE and missile structures designers.

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ENGINEERING WRITERS with 2 years college and 1-3 years experience in preparation of TCTO's; Operations, Maintenance, and Overhaul manuals.

BASE ACTIVATION: Design or liaison engineers with BS in ME or EE and experience in electrical or mechanical systems are required for liaison work at missile launching complexes, or design support work on launch control equipment, propulsion systems, automatic programming and missile checkout equipment operations. Assignments are at Salina, Kansas; Lincoln, Nebraska; Altus, Oklahoma; and Abilene, Texas. Also some openings in San Diego.

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Technical openings also exist in other specialties. Write Mr. R. M. Smith, Industrial Relations Administrator-Engineering, Dept. 130-90, Convair Astronautics, 5673 Kearny Villa Road, San Diego 12, California. (If you live in the New York area, please contact T. Cozine, manager of our New York placement office, CIrcle 5-5034.)

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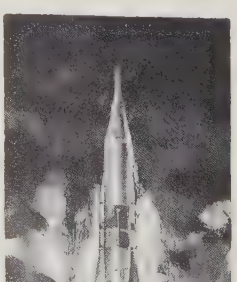


CONVAIR DIVISION OF GENERAL DYNAMICS

Thermal switches and transducers for discreet and continuous temperature control

by **William C. Moodie,** Vice President for Engineering, Control Products, Inc.*

WHILE THERE ARE a number of new and esoteric methods and devices for sensing and controlling temperature, these jobs most often will continue to be done by a limited variety of time-tested temperature transducers and controllers. Outstanding among these reliable devices is the thermal switch, widely used as a warning or protective device to develop or interrupt a signal when the temperature has reached a critical value.

There are three basic types of thermal switches: rod-and-tube, bimetallic, and liquid, gas, or vapor.

The *rod-and-tube* thermal switch is based on the principle of differential expansion—it uses two metal elements with different coefficients of expansion. The displacement of one element with respect to the other, which depends on the change in temperature, opens or closes contacts.

The simplest thermal switch is the bimetallic one. Its sensitive element is a strip made up of welded layers of metals with different coefficients of expansion. With a change in temperature, the welded layers warp or bend, producing a force that can be applied to open or close contacts at a preset temperature.

Metallic bulb is sensing element

The most complex thermal switches are the liquid, gas, and vapor types. The sensing element of such a switch is a metallic bulb whose size may range from ½ in. in diameter and 2-4 in. in length, to ⅛ in. in diameter and several feet in length. A capillary tube extends from one end of the bulb, and is attached, at its far end, to a diaphragm or bellows designed for linear motion in one direction.

The bulb is filled with a gas, vapor, or liquid that expands at a known rate for a known increase in temperature. Generally, this range is limited for any given fluid. As the temperature increases, the liquid expands, and force is transmitted through the capillary tubing to the diaphragm. The movement of the diaphragm directly operates contacts, trips a microswitch, or activates a Bourdon gage.

A second general and important class of temperature sensors change resistance or generated voltage in response to a temperature difference: thermistors—(with both negative and positive temperature coefficients), resistance bulbs, and thermocouples.

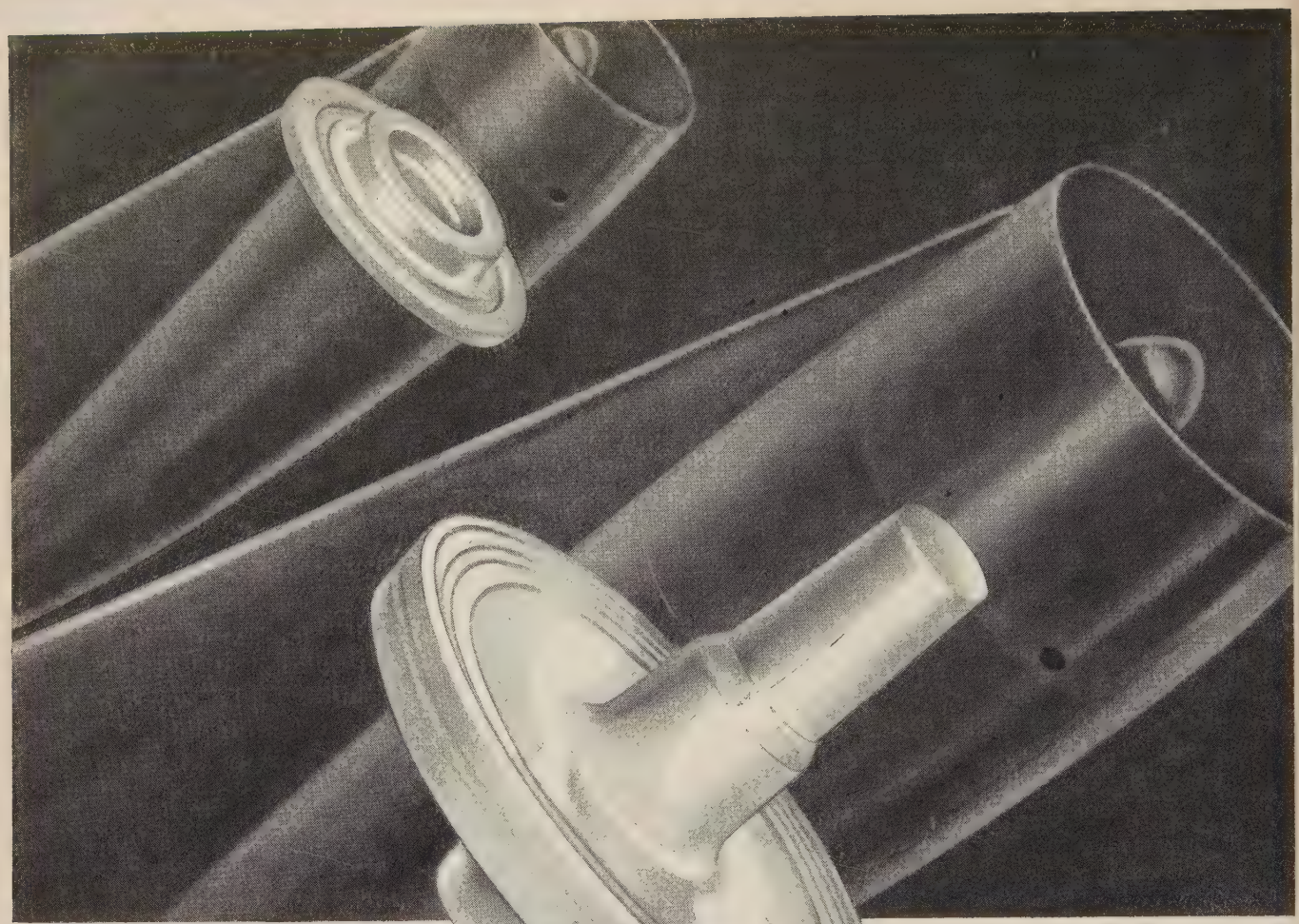
The *thermistor* is a resistance element made from semiconductor materials. The most widely used types have a very high negative temperature coefficient (NTC), but there are also thermistors with a positive temperature coefficient (PTC). Both kinds have a wide change in resistance for a relatively small change in

* Control Products, Inc., Harrison, N.Y.

Today as in the past, a limited number of seasoned thermal switches or transducers is used in most applications requiring the collection of temperature data or protection against overtemperatures. Both the rod-and-tube and bimetallic thermal switches operate on the differential expansion of metals, which is applied to open or close contacts or to trip a snap-action switch. The liquid, gas, or vapor switches derive their actuating force from the expansion of a fluid in a sensor bulb and use it to move a diaphragm, bellows, or Bourdon gage.

These switches are self-actuated and require no auxiliary amplifiers or other equipment, but they are limited by relatively narrow ranges. For operation over a wide, stepless band of temperatures, resistance elements, thermistors, and thermocouples can be used, which, however, require additional equipment.

This article reviews the factors involved in the selection and application of these devices and, in a comprehensive table, summarizes their significant characteristics.



Diameter, 29″, Weight, 1000 lbs.
Material, Astroloy

Diameter, 24½″
Weight, 191 lbs.
Material, Titanium

Diameter, 19″
Weight, 143 lbs.
Material, High-strength steel

Length, 22″
Weight, 45 lbs.
Material, High-strength nickel-base alloy

Length, 18″
Weight, 10 lbs.
Material, Ironbase, high-temperature alloy

Diameter, 10″
Weight, 45 lbs.
Material, Inconel X

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temperature. The PTC thermistors are used mainly in motor protection circuits; the NTC type has more general application in military and commercial equipment.

Resistance bulbs are used chiefly as laboratory standards or when high accuracy and long life are required. Their response to temperature changes is fairly slow, because of the mass of the bulb. They cost considerably more than *thermocouples*—which are available with accuracies that are as good as those of resistance bulbs but deteriorate much faster.

In instrumentation and in lab work, thermocouples are used almost exclusively, since they are cheap, rugged, easy to protect from corrosive atmospheres, and easy to replace. In addition they have a number of advantages over thermistors, particularly for instrumentation work, because they come in a greater variety of sizes and temperature ranges. Iron-Constantan, Chromel-Alumel, copper-Constantan, platinum-rhodium, and Chromel-Constantan are some of the more common standard types of thermocouples.

Environment determines choice

The thermal choice and method of application of a switch or sensor in any given case may depend largely on the device's operational environment. For example, not all the thermal switches have the same resistance to vibration. A snap-action design has low resistance, because the switch mechanism is in an unbalanced position. Shock or vibration can cause the blade to jump prematurely, especially when the switch is near its actuation point. On the other hand, most of the slow make-and-break switches are not affected by strong vibrations (with the possible exception of the liquid, gas, and vapor types).

Resistance to temperature extremes varies considerably. With self-contained snap-action switches, the problem is that the snap-action blade itself usually will not withstand more than 600 deg F. The slow make-and-break switches can take much higher temperatures —often as much as 2200 deg F on the probe itself.

Bimetallic switches generally are restricted to 1000 deg F or less. The maximum temperature of a gas, liquid, or vapor switch depends primarily on the type of fluid in the bulb.

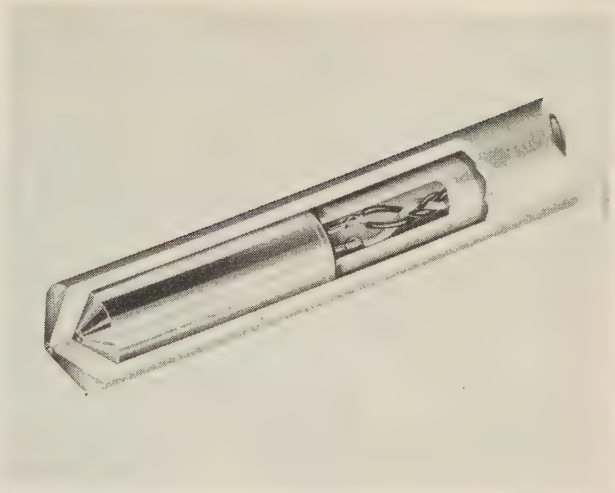
Switches are corrosion-resistant

Because the thermal sensing elements are usually made of stainless steel, the three major types of thermal switches are protected against corrosion.

Environmentally, thermocouples, thermistors, and resistance elements perform equally well, with one or two exceptions. Thermocouples and thermistors generally can take considerable mechanical abuse; resistance elements tend to break down under vibration unless they are specially constructed. The durability of thermistors depends entirely on their construction. Those encased in glass are naturally delicate and can't be used under vibration.

Thermocouples and thermistors as such usually are not corrosion-resistant. However, they can be encased in non-corrosive tubes. Resistance elements, on the other hand, are usually enclosed in a stainless-steel bulb and are therefore non-corrosive.

The *Table* compares the significant characteristics of the various thermal transducers and controllers. One of the most important is sensitivity, or the smallest temperature change that will produce a usable output from the transducer or associated equipment. It is affected by the differential, or the maximum temperature difference between "on" and "off" control points for a given rate of temperature change.



RESISTANCE temperature sensor designed by Rosemount Engineering, Minneapolis, Minn., is designed to operate at radiation levels of 500 rad/hr.

For thermal switches, sensitivity depends on the repeatability of the switch set point as well. This repeatability is the ability of an instrument to maintain its set point or accuracy over a long operating life at rated current and voltage. In the case of the slow make-or-break switches, repeatability is limited mostly by contact erosion. For snap-action switches, the limiting factor is the life of the snap blade.

The electric current rating depends on the type of switch, the type of contacts, the life expectancy, required repeatability, the differential, and the physical size of switch. For example, in a miniaturized snap-action switch heavy current drain cannot be maintained. For such a drain, a heavy snap-action blade and large contacts are needed.

Arc-over can present a problem

In the slow make-or-break thermal switches, increasing the size of the contacts does not increase the current rating in the same proportion. Under heavy loads, furthermore, these switches tend to arc over when deactuated. No such arc-over problem is posed by snap-action switches, which is one of the reasons why they are used.

Application requirements and auxiliary equipment are the two most important factors in choosing thermal sensors and controllers. Thermocouples, for instance, are rarely used in airborne systems because their instrumentation is too bulky and requires relatively high power. Switches are preferred in this case.

Sometimes, however, there is really no choice. Thermocouples often must be used because thermal switches are too large. If a system is designed to read many points, and all these points can be sensed by thermocouples connected to a single recorder, thermal switches would be impractical. The total weight of, say, 50 thermal switches might well be greater than the weight of a single, compact control thermocouple instrument.

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Subcarrier oscillators designed and built by Dorsett Electronics are standard equipment in the FM telemetry systems of both the Advanced Terrier and the Tartar missiles, built by Convair/Pomona, Convair Division of General Dynamics.

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Temperature Transducers and Controllers

	Thermal Switches					
	Rod and Tube		Bimetallic		Liquid, Gas or Vapor	
	Snap Action	Slow Make and Break	Snap Action	Slow Make and Break	Snap Action	Slow Make and Break
Max. range (deg F)	1100	−100 to 2000	−100 to 600	−100 to 900	−150 to 1000	−100 to 650
Life (no. of operations)[1]	100,000 to 1,000,000	100,000 to 1,000,000	100,000 to 500,000	100,000 to 1,000,000	100,000 to 1,000,000	100,000 to 1,000,000
Sensitivity (deg F)	1–10	0.1	1–10	0.1	1–10	0.1
Max. transient sensor temperature (deg F)[2]	1500	2100	700	1000	1200	700
Repeatability (deg F)[3]	10–20	5	20–50	5	10–20	5–10
Min. differential (deg F)	5–10	0.5	5–10	0.5	5–10	0.5
Current rating (amp)	5–25	½–10	5–10	½–10	5–25	¼
Type of control	on-off	on-off	on-off	on-off	on-off	on-off
Auxiliary Equipment	none	none	none	none	none	none
Provision for adjustment	yes	yes	no	yes	yes	no
Hermetic Sealing Available	yes	yes	yes	yes	yes	yes
Cost						
Sensor	$10–75	$10-75	under $10 & up to $75	under $10 & up to $75	$25 & up	$10–75
Transducer	$10–75	$10-75	under $10 & up to $75	under $10 & up to $75	$25 & up	$10–75

	Thermocouples	Thermistors	Resistance Elements
Max. range (deg F)	−460 to 5400	−200 to 900	−460 to 5000
Life (no. of operations[1])	varies[4]	varies[4]	varies[4]
Sensitivity (deg F)	0.05	0.05	0.05
Max. transient sensor temperature (deg F)[2]	5400		
Repeatability (deg F)[3]	5	5-10	5
Current rating (amp)	5-25	5-25	5-25
Type of control	on-off or modulating	on-off or modulating	on-off or modulating
Auxiliary Equipment	electronic or electromechanical balancing system	electronic or electromechanical amplifying system	electronic or electromechanical amplifying system
Provisjon for adjustment	aux. equipment only	aux. equipment only	aux. equipment only
Hermetic Sealing Available	sensor-transducer only	sensor-transducer only	sensor-transducer only
Cost			
Sensor	under $10 & up to $75	under $10 & up to $75	under $10 & up to $75
Transducer	under $10 & up to $75	under $10 & up to $75	under $10 & up to $75
Auxiliary Equipment	$75 & up	$75 & up	$75 & up

(1) Contact life generally is the limiting factor and in turn depends on electric load, temperature range, and other factors. (2) Dependency on application and temperature. For short periods without affecting calibration. The actual value in practice depends on the materials used. (3) Set-point deviation of an average unit at a minimum life of 100,000 operations. (4) Depending on application and temperature.

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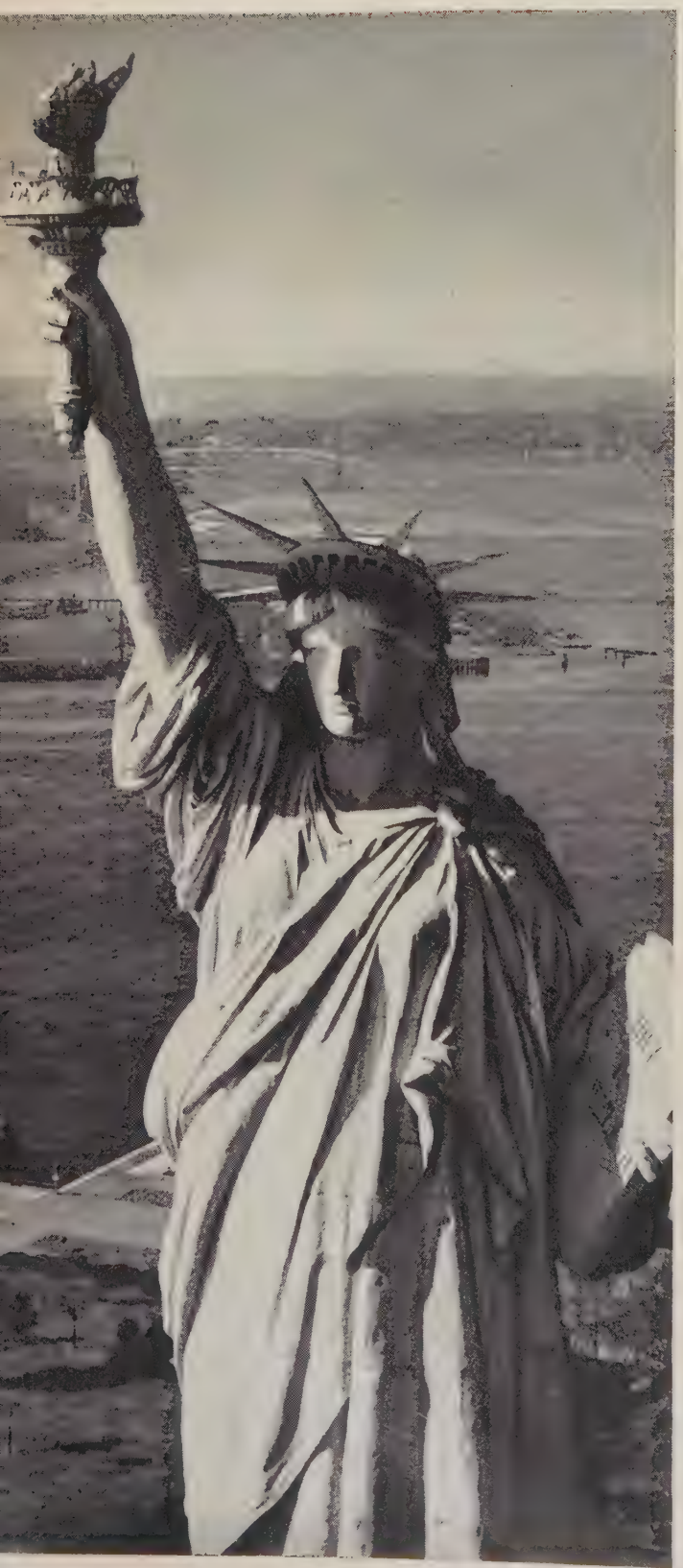

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SPERRY

ELECTRONIC TUBE DIVISION

SPERRY RAND CORPORATION
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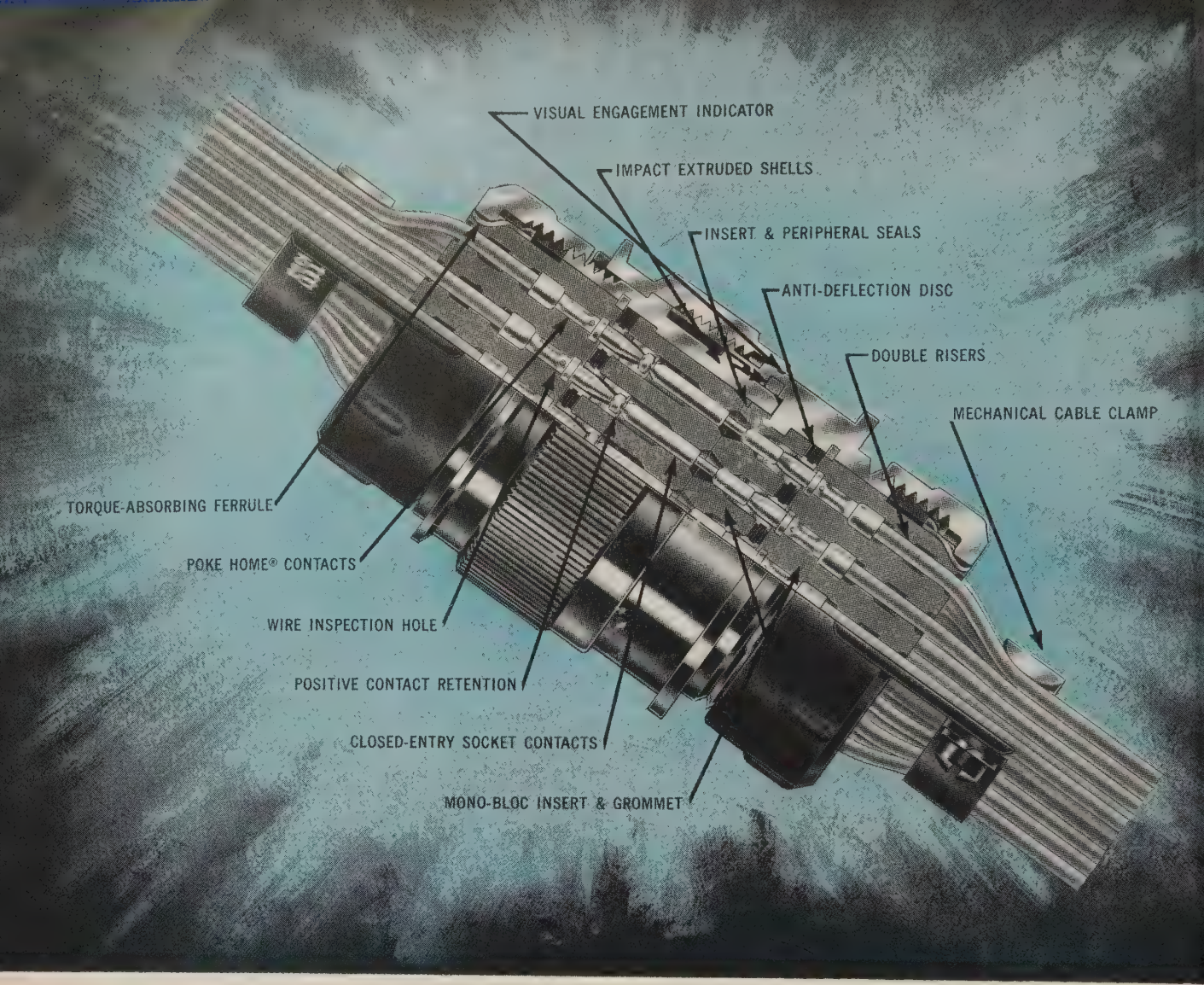

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AMPHENOL 48 SERIES CONNECTORS TO MIL-C-26500 provide you with these performance features:

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- Supports 1500 volts RMS at high altitudes (Sea level to 350,000 feet) fully mated.
- Altitude immersion resistant after 10 contact removal and insertion cycles on all contacts. (Maintains 5000 megohms I.R. after three altitude cycles.)
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Martin-Orlando solves guidance problem and unplugs information bottleneck

ENGINEERS AT THE MARTIN CO., Orlando Div., Orlando, Fla., have come up with a solution to a problem that has long plagued guidance engineers: the restraining torques generated in the course of measurements of gyroscopic angular deviations. Often unbalanced about the zero-deviation position, these torques create a direct error that increases with time. Because they are affected by magnetic fields and radial play, they frequently also cause errors in the measured angular deviation. Electromagnetic pickoffs have reduced but not eliminated these disturbing effects.

Early in 1959, John Elpi became interested in a no-restraint readout device being developed by Bill Routh for use with a non-gyro reference. Elpi and Routh decided to try to adapt the pickoff to an air-bearing gyro. Concentrating on the use of polarized light as a null-sensing device, they were able to come up with a working model in less than six months. Evaluation tests showed that they had developed a pickoff technique that can be applied to any servoed gyro and gives extremely fine resolution in measuring angular deviation without exerting restraining torques on the element under measurement.

Elpi and Routh relied on the basic physical principle that, when the light intensity on each of two properly loaded silicon photovoltaic cells of equal conversion efficiency is equal, the voltage (V_0) is zero (*Fig. 1*). By decreasing the light intensity of one of the cells, a

A simple light-sensitive pickoff, this article shows, can be used in measuring gyroscopic angular deviations to prevent restraining torques, which have long bothered guidance engineers. This is the kind of minor invention that, although it would be of interest to many aerospace engineers, all too often simply does not get around—not even in the inventor's company. There is no good reason, however, why it cannot get around. As this article also shows, all it takes to unplug the bottleneck in intra-company technical communications is an awareness of the problem and a simple but well-conceived system for overcoming it.

How Useful Are Light-Sensitive Gyro Pickoffs?

Advantages	Limitations
High resolution	fails if light source fails
No restraining torques	limited by the polarizer to allow a maximum resolution of five seconds of arc
Adaptable to any servoed gyro	
Principle is applicable to the development of optical synchros	

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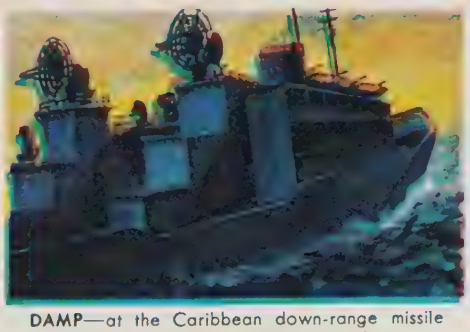
Incorporating revolutionary and advanced electronic equipment, TIROS was designed, developed and built by RCA's Astro-Electronics Division for National Aeronautics and Space Administration. Within its small circumference are miniature TV cameras, tape recorders, TV transmitters, command receivers, timing mechanisms, beacons and telemetry equipment. In addition, it carries new scanning and non-scanning Infra-red Sensing Devices, developed by NASA, to measure and record the heat radiation of the earth and its cloud cover, and a revolutionary new Magnetic Orientation Device to capitalize on the effects of the earth's magnetic field and maintain favorable orientation of the satellite for long periods.

BMEWS—RCA Electronics Equipment and Systems contribute to the alert status of the Nation's vast outer perimeter early warning system.



DAMP—at the Caribbean down-range missile testing "slot," the highly complex DAMP vessel is equipped with RCA electronic tracking devices.

ATLAS—an RCA-developed checkout and launch system reduces substantially the "countdown" period required for launching this missile.

RCA developments in miniaturization, reliability, computing and overall electronic activities are contributing to many of the nation's leading space and missile projects. For information describing new RCA scientific developments, write Dept. 434, **Defense Electronic Products,** Radio Corporation of America, Camden, N.J.

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Here are highlights:

Fixed base—AMF's experience in designing automatic machinery was utilized in the 10,000-lb. AN/FPS-19, the famous "Dew Line" antenna, designed and built by AMF to operate unfailingly under fantastic arctic conditions.

Mobile—AMF designed and built AN/TPQ-10 precision tracking antenna that demounts into shock-resistant, immersible components. AN/MPS-4 and 16 are AMF-designed trailer and truck-mounted types.

Stabilized base—Design and fabrication of SX, AN/SPS-8B High Gain Antenna, AN/SPS-3 Dual Foster Scanner.

Precision pedestals, theodolites—AMF's Precision Instrument Mount is controlled by optical digital discs accurate to 0.05 milliradans. It tracks missiles and satellites.

Rotary joints—A special AMF capability requiring utmost precision in design. Example: multichannel joint for AN/FPS-24 System.

Scanners, Feeds, Servos and *Drives,* Multichannel Phase Shifters, Hydrostatic Bearings, Slip Rings, Programming, Test, Control and Display systems are all part of AMF's radar capabilities. AMF also operates its own test ranges.

For more information, write American Machine & Foundry Company, Government Products Group, 261 Madison Avenue, New York 16, N.Y.

AMF

. . . . AMERICAN MACHINE & FOUNDRY COMPANY

voltage is generated that is directly proportional to the difference in light intensity between the two cells.

Figure 2 shows how these cells are masked. A light source is observed through fixed and movable polarizer segments by the photosensitive detectors. In the reference position, the axis of polarization of the movable polaroid segment is set at 45 deg with respect to the fixed segments. Angular motions of the movable polarizer segment cause an imbalance of light on the photocells, which in turn generates a voltage equal to cos 20 of the angle of polarization.

One of the most remarkable things about the Elpi-Routh pickoff —which costs $150-200 to produce (including preamplifier)—is that it will benefit not merely its inventors and the people working directly with them. Martin-Orlando sees to it that all its engineers learn about any new solution to a problem developed by one of its engineers or groups.

The case of the engineer who accidentally discovers that the problem that has been giving him nightmares was neatly solved two months ago by a fellow engineer two departments down the line is not at all exceptional in aerospace electronics. Like so many things, the problem of spreading technical information begins at home, in your own company.

Martin-Orlando is quite aware how wasteful bottlenecks in intracompany communications can be, and the editorial office of its Technical and Research Engineering Departments is trying hard to smooth the flow of technical information

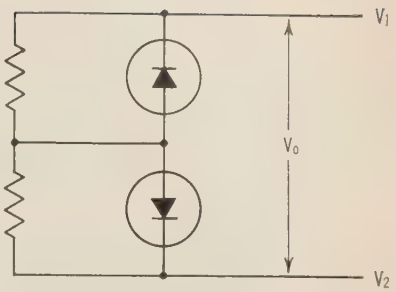


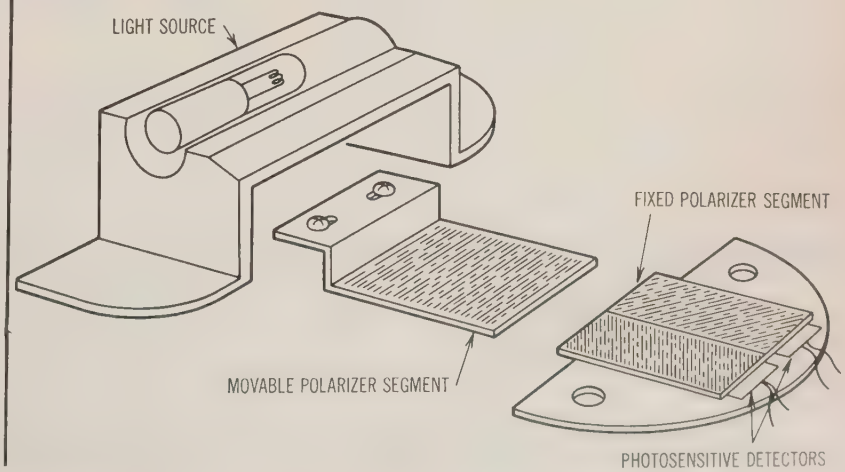
FIGURE 1: Basic principle of light-sensitive gyro pickoff.

between engineering and scientific groups. One of its most effective devices is a series of irregularly published monographs aptly entitled "Item" and distributed to all the company's engineers.

Each "Item" is devoted to a new device or technique that has been developed by one engineer or one group but, in the management's opinion, should be generally known —like the Elpi-Routh pickoff. Every bit of information given here on this pickoff came from an "Item."

"Items" are printed photo-offset on letter-size sheets from typed masters. They are brief, simply written, and clearly organized—the "Item" on the gyro pickoff was subdivided into four sections of about 5-10 lines each and headed "Problem," "Solution," "Creating the Voltage," and "Masking the Cells." In addition, it presented the two illustrations (as black- and-white line drawings) and the table accompanying this article, gave the production cost, and noted Routh's and Elpi's telephone extensions.—**JH**

FIGURE 2: Masking of photovoltaic cells.



No. 47 on Reader Service Card

ENGINEERS: you can probe the propulsion future in

CONNECTICUT or FLORIDA

EAST HARTFORD ENGINEERING FACILITY

WIDE-RANGE OPPORTUNITIES—Pratt & Whitney's main plant facility in East Hartford, Connecticut, is expanding its operations in advanced research and development projects and long-range planning. In addition to our established capability in the flight propulsion field, we are exploring the fringe areas of technical knowledge in aerospaceplane propulsion systems, magnetohydrodynamics, thermionic, and thermo-electric conversion; solar energy conversion, supersonic combustion, fuel cells, and nuclear power for military, space, marine, and industrial applications. Other engineering studies are being conducted on advanced turbojets and turbofans including regenerative turbine engines and supersonic transport propulsion systems.

In support of our engineers we have the world's largest privately-owned installation for the development-testing of advanced powerplant and high-power rotating machinery as well as the latest in automatic data acquisition systems and computer facilities.

EDUCATIONAL ADVANCEMENT—Engineers at Pratt & Whitney Aircraft have an unusually fine opportunity to continue their formal education under the United Aircraft Corporation Graduate Education Program with full tuition costs being paid by the company directly to the institutions involved for those who successfully complete the requirements for advance degrees. Excellent courses are offered at the Rensselaer Polytechnic Institute Hartford Graduate Center located a few miles from our East Hartford Plant as well as at other fully accredited schools in Connecticut.

EXCELLENT LIVING CONDITIONS—Pratt & Whitney Aircraft is ideally located in picturesque New England, midway between Boston and New York. Year round recreational facilities abound at the seashore, lakes and mountains.

Openings exist at all levels of experience for engineers and scientists who want to work as part of a team dedicated to maintaining Pratt & Whitney's position of leadership in the future.

Please submit your resume, including minimum salary requirements, to:

MR. P. R. SMITH, OFFICE 75
PRATT & WHITNEY AIRCRAFT
410 MAIN STREET
EAST HARTFORD 8, CONNECTICUT

FLORIDA RESEARCH AND DEVELOPMENT CENTER

From out of Florida comes the power to put man into the vast outer reaches of space or propel him at record speed in the atmosphere. The locale is the seven-thousand acre site of Pratt & Whitney Aircraft's Research and Development Center at West Palm Beach, Florida.

ENGINEERING PROGRESS—Within the few short years since its activation, the Center's creative achievements have assumed truly significant proportions. Today the material results are embodied in the nation's first liquid hydrogen rocket engine, the LR-115, scheduled for Centaur and Saturn space vehicles; and a new Pratt & Whitney J-58 turbojet engine capable of propelling giant aircraft at Mach 3 speeds. Our engineering accomplishments and versatility have well equipped us for challenging new assignments in developing new concepts and techniques in today's space age. Current studies in applied research include space vehicle mission analysis, advanced propulsion systems studies, advanced fabrication techniques, advanced control systems, and studies in the cryogenic field.

EXCELLENT FACILITIES—The adequate support of such engineering feats demands the finest of facilities. The Florida Research and Development Center is one of the world's most complete technological facilities devoted to aerospace propulsion. These facilities provide for the accelerated development of advanced rocket motors, high Mach turbojet engines, full-scale rocket components, fuels and fuel handling. And further assisting our engineers are comprehensive automatic data acquisition and processing systems, including the latest in computing facilities.

IDEAL ENVIRONMENT—The calibre of men we seek is typified by Pratt & Whitney engineering advances. We invite communications from engineers and scientists who would enjoy working in a vacation climate. Just a few minutes from the Center are pleasant communities providing year-round golf, water skiing, fishing, boating, swimming or just plain sunning on golden beaches.

Please submit your resume, including minimum salary requirements, to:

MR. J. W. MORTON, OFFICE 75
PRATT & WHITNEY AIRCRAFT
WEST PALM BEACH
FLORIDA

All replies will be handled promptly and in complete confidence.

PRATT & WHITNEY AIRCRAFT

DIVISION OF UNITED AIRCRAFT CORPORATION

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

Check Inquiry Form on Page 141

Space/Aeronautics

CONFIDENTIAL

July 1961

(good until 9/15/61)

Employment Inquiry Form

(Not an application for employment)

THIS INQUIRY FORM is a service that makes it easier for the interested reader to explore employment opportunities with organizations featuring recruitments advertising **in this issue.**

To use this Form, follow these simple steps:

(1) Tear out this page.

(2) Check off the organization(s) listed below whose employment offers are of interest to you. **Use typewriter or pencil.**

(3) Turn to the back page of this Form and answer the questions on it.

(4) Mail this Form (in a stamped envelope) to:

Reader-Service Dept.
SPACE/AERONAUTICS
205 East 42nd St.
New York 17, N.Y.

We will do the rest and promptly forward a copy of your Inquiry Form to each of the organizations you have checked. Depending on their specific personnel requirements they will get in touch with you at your home.

I am interested in the employment opportunities at:

☐ AiResearch Mfg. Co.	144	☐ Motorola, Inc.	101
☐ Boeing Airplane Co.	145	☐ Northrop Aircraft, Inc.	147
☐ Convair; Astronautics Engineering Div.	123, 124, 125, 126	☐ Pratt & Whitney	140
☐ Garrett Corp.	144	☐ Space Technology Labs.	36
☐ Lockheed Aircraft Corp.; Georgia Div.	146	☐ System Development Corp.	84
☐ Minneapolis-Honeywell Regulator Co.; Aeronautical Div.	143	☐ United Aircraft Corp.; Pratt & Whitney	140

OTHER (Some organizations' recruitment advertising in this issue may have arrived too late for inclusion in the above list. If you are interested in the employment offers of any of these organizations, just note its name and the page number of its advertisement in this space. Please refer only to ads keyed to this form.): _____

_____

_____

NOTE: If you have an immediate interest in any special employment opportunity advertised in this issue and would like to give more details about your qualifications than can be noted on this Form, we advise you to send your resume directly to the person or department given in the advertisement. We'd appreciate it if you'd mention SPACE/AERONAUTICS in your application.

Space/Aeronautics

CONFIDENTIAL

Employment Inquiry Form

July 1961
(good until 9/15/61)

Please type or print (with pencil)

(Not an application for employment)

FIELDS OF INTEREST (in order of importance, note the general fields in which you would like to work—e.g., basic research, dynamics, structures, rocket propulsion, electronic systems, pneumatics, testing, materials, production, ground support, etc.): _____

SPECIALIZED JOB EXPERIENCE (describe the specific technical areas in which you have worked—e.g., flutter, fatigue, fuel systems, circuit miniaturization, servo systems, hydraulic pumps, tool engineering, orbit mechanics, telemetry, data processing, wind tunnel testing, etc.): _____

JOBS AND EDUCATION

List your last 3 employers:

EMPLOYER	CITY & STATE	YEARS EMPLOYED	JOB TITLE OR FUNCTION

List your college and university degrees:

SCHOOL	YEARS ATTENDED	DEGREE

Special Training _____

PERSONAL DATA

AGE ..... U. S. CITIZEN ☐ YES ☐ NO If not, when do you expect to become a citizen? .....

Name: .....

Home Address: .....

Home Telephone .....

Make sure you have checked the companies you are interested in on the other side of this Form. Then put the Form in a stamped envelope and mail it to **Space/Aeronautics**

HONEYWELL AERO
Opportunity for growth

New and exciting programs, such as project Dyna Soar, have created these challenging career openings for engineers and scientists

Sr. Metallurgist—Exotic Metals to develop methods of brazing and solid state welding of exotic metals such as Beryllium; growing and fabricating single crystals of aluminum, Niobium and others for use in control devices for space vehicles requiring extreme accuracy; defining smoothness and waviness of surfaces and their measurement; surface treating to gain unique properties.

Sr. Chemist or Chemical Engineer with experience in vacuum evaporation, vapor reduction, and electro-deposition of coatings on metallic and non-metallic base materials or experience with any of the coating methods. Must be capable of developing processes providing uniform adherent deposits of materials having unique properties suitable to advanced gyro and circuitry development.

Sr. Systems Analyst. Must be well grounded in math and have 4 years' experience in analysis of aircraft stability and control. Familiar with both analog and digital computers and capable of applying various types of stability criteria such as phase amplitude plots, root locus, etc. Broad experience in circuit design and closed loop servo-systems.

Transistor Circuit Applications. Experience in audio frequency circuit design or servomechanisms, circuits utilizing transistors, diodes, transformers, magnetic amplifiers, etc. Familiarity with military design requirements desirable.

Electronics Packaging Engineer. 2 years' experience in the basic development of microminiature devices or design of one or more types of electronic components such as semiconductors or resistors. Experience with military hardware requirements desirable.

Senior Electronics Engineer to do analysis of complex servo systems and related circuitry. Must be able to translate analysis into circuitry. Four to six years' experience.

Send your resumé or request for further information to: Mr. Clyde Hansen, Technical Director, Aeronautical Division, 2654 Ridgway Road, Minneapolis 40, Minn. All qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin.

To explore professional opportunities in other Honeywell operations, coast to coast, send your application in confidence to: Mr. H. G. Eckstrom, Honeywell, Minneapolis 8, Minnesota.

Honeywell

Military Products Group

Check Inquiry Form on Page 141

• *Advanced hydrogen systems being developed by The Garrett Corporation solve the problem of keeping men alive and equipment operating for long periods of time in future satellites and space capsules.*

Engineers at The Garrett Corporation's AiResearch Manufacturing Divisions are dealing with challenging problems in fast-moving fields.

Diversification of effort and vigorous leadership have made Garrett the world's largest manufacturer of aircraft components and systems and a leader in specialized missile and spacecraft systems.

Major fields of interest are:

- Environmental Control Systems—Pioneer, leading developer and supplier of air conditioning and pressurization systems for commercial and military aircraft, and life support systems for satellites and space vehicles.
- Aircraft Flight and Electronic Systems—Largest supplier of airborne centralized flight data systems; also working with other electronic controls and instruments including missile and submarine applications.
- Missile Systems—Largest supplier of accessory power units, AiResearch is also working with hydraulic, hot gas and hydrogen systems for missiles, liquid and gas cryogenic valves and controls for ground support.
- Gas Turbine Engines—World's largest producer of small gas turbine engines, with more than 9000 delivered in the 30–850 hp class. Studies include industrial and nuclear applications.

Excellent positions are available for qualified men with M.S., Ph. D. and Sc. D. degrees for work in these areas.

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

Send resume to: G. D. Bradley

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

ATTENTION ALL ENGINEERS

If you are seeking new job opportunities be sure to read all employment advertisements in this issue—both in this Special Section and throughout the magazine

Check Inquiry Form on Page 141

Work better,
live better
in the uncongested
Pacific Northwest.

Design based on Boeing supersonic transport study.

There's challenge and a long-range future at Boeing for

STRUCTURAL, MECHANICAL AND AERONAUTICAL ENGINEERS

This supersonic skyliner of the future is one of many advanced projects underway at the Transport Division of Boeing. Other programs offering engineers scope and a chance to grow in professional stature are the newly announced Boeing 727 jetliner and continuing programs in connection with the famous 707 and 720 jetliners.

There are openings at Boeing, now, for structural, mechanical and aeronautical engineers. Although aircraft experience is desirable, training assignments are available, on a selective basis, to graduate engineers in other fields who wish to apply their capabilities to aircraft projects.

At Boeing you'll be working with the world leader in the field of multi-jet aircraft. You'll be backed by unexcelled research facilities, including the largest, most advanced wind tunnel installation in private industry. You'll be working in a dynamic career environment that's conducive to rapid advancement.

The Boeing Transport Division is located in the uncongested Pacific Northwest, noted for mild year-round climate, nationally famous recreational facilities, excellent schools and housing, and healthful outdoor Western living for the whole family.

MAIL COUPON TODAY

Mr. Ivan Phillips, Transport Division, Boeing Airplane Company, P.O. Box 707–8RG, Renton, Wash.

NAME

ADDRESS CITY STATE

DEGREE(S) HELD

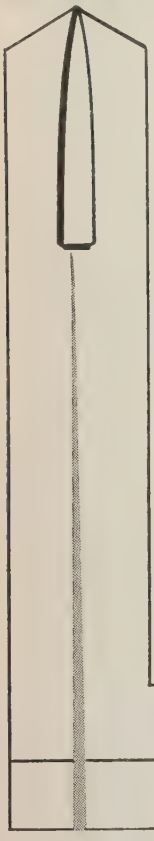
SCHOOL(S), YEAR GRADUATED

FIELD OF INTEREST YEARS EXPERIENCE

TRANSPORT DIVISION **BOEING**

Check Inquiry Form on Page 141

DESIGN ENGINEERS



Inquire about new opportunities for highly qualified engineers in the fields of avionics, controls, electrical and electronics, empennage, equipment, fuselage, hydraulics, landing gear, power plant and wing design.

Requires
AE, ME, EE or related degree with aircraft or missiles experience preferred.

Combine work in an exciting professional environment with living in one of the finest cities in the country.

Write: Hugh L. Gordon, Professional Employment Manager
Lockheed Aircraft Corporation
840 West Peachtree St.
Atlanta 8, Georgia

LOCKHEED/GEORGIA

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

Check Inquiry Form on Page 141

Investigating Employment Opportunities?

Want more information about employment opportunities offered by companies advertising in this issue? Then be sure to give complete data about your job interests, experience and education when filling in the "Employment Inquiry" form.

Although not an application for employment, it provides employment managers with information to evaluate your capabilities—and in turn gives your request immediate consideration.

Check the "Employment Inquiry" form for details.

ATTENTION EMPLOYMENT MANAGERS

This new "Employment Opportunities" section allows you greater choice in positioning advertisements—in keeping with your recruitment objectives.

If the purpose of your campaign is to alert readers to immediate job openings you'll find the new section ideal for this need.

If, on the other hand, your aim is to acquaint readers with your organization—the scope of its operation, new projects getting underway, extra benefits, etc.,—you may find any other part of the magazine more suitable for this purpose.

But no matter where you position your employment advertising, your company will be listed on the "Employment Inquiry" form which appears in this section.

Although not an application for employment, it provides you with detailed information about technical personnel interested in your company. After evaluating their specialized job interests, experience and formal education —which must be included in the form before it is sent to you —you can personally contact those best qualified for the job.

When scheduling your recruitment advertisements in Space/Aeronautics, be sure the insertion order specifies where you want the advertisement to appear—"run-of-book" or in the "Employment Opportunities" section.

NEXT STOP: MARE IMBRIUM

One of the primary needs in the next generation of our space program is for a reliable "space bus" to carry a variety of exploratory packages to the moon and possibly the near planets. Once it is injected into a lunar or planetary trajectory, this bus will guide itself to its destination, accomplish a soft landing, activate and release its payload.

The problems involved in the design of such a vehicle, and of the many kinds of lunar and planetary exploration packages it might be called on to carry, are being intensively explored at Northrop. These investigations cover guidance, communications and position sensing systems, thermal and environmental conditioning, structural and material development, systems integration, trajectory and error analysis, computer design, self-contained, automatic ground support systems, and a host of other essential areas.

If you are interested in taking part in this effort, and have the experience, ability and creative insight to work well in advance of the state of the art, there may well be a place for you at Northrop.

All qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin.

NORTHROP

NORTHROP CORPORATION, BEVERLY HILLS, CALIFORNIA
DIVISIONS: NORTRONICS/NORAIR/RADIOPLANE

Check Inquiry Form on Page 141

Announcing the first of

a New TECHNICAL REFERENCE SERIES

"GROUND SUPPORT TECHNOLOGY"

To be published November 1961

AVAILABLE TO ALL INDUSTRY TECHNICAL MANAGEMENT CONCERNED WITH GROUND SUPPORT

Two Ways To Get Your Copy of GROUND SUPPORT TECHNOLOGY

- If you receive a personal copy of SPACE/AERONAUTICS each month, you will automatically receive a copy of the reference with your November issue.

- If you do not receive a personal copy of SPACE/AERONAUTICS you can still obtain a copy of the reference.

  1) Make your request in writing (on company letterhead) to Mr. Roy Ellison, SPACE/AERONAUTICS, 205 East 42nd Street, N.Y. 17, N.Y. or

  2) Make your request on the Reader Service Card in this issue. Just mark it: "Request copy of November GROUND SUPPORT TECHNOLOGY reference."

All requests must be in the New York office by September 30, 1961

The Reference Will Feature

- **Index To Industry Capabilities**

  The index serves as a time-saver for systems engineers looking for GSE subcontractors . . . team members on GSE projects . . . who want to know how many and which companies can propose on a specific GSE contract.

- **Company Specialties and Contract Experience**

  Shows depth of each company's GSE experience and specialties . . . highlighting area of capabilities, recent contracts, available literature on each company's GSE capabilities.

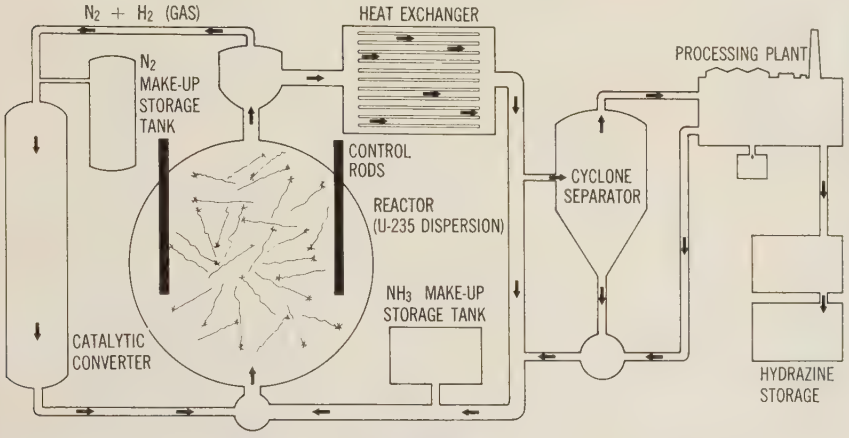
- **Design Trends and Requirements**

  Cover key design problem areas . . . each with an analysis of the most important design trends. The section also summarizes requirements as seen by NASA, prime weapon system contractors, GSE project engineers and users.

Space/Aeronautics A CONOVER-MAST PUBLICATION • 205 EAST 42ND STREET, NEW YORK 17, N.Y.

equipment preview

I—Materials and Production Equipment



FISSIO-CHEMICAL REACTOR PRODUCES HYDRAZINE FROM AMMONIA

Experimental results with in-pile apparatus have proved the feasibility of producing hydrazine from liquid ammonia, according to Aerojet-General Nucleonics, Box 77, San Ramon, Calif. Engineers at Aerojet estimate that a fissio-chemical reactor setup can produce hydrazine from ammonia at an amortized cost of about 15-40 cents per pound (as against present prices of over two dollars a pound).

Uranium 235, suspended in ammonia, forms the critical assembly in Aerojet's concept of a hydrazine production reactor. The fission fragments of uranium break up ammonia molecules, which recombine to form stable hydrazine and hydrogen. The continuously circulating stream becomes subcritical as it leaves the reactor.

Ammonia, hydrazine, and uranium are drawn from the reactor stream. A cyclone separator removes the uranium 235 and feeds it back into the reactor. The hydrazine and ammonia are separated, fission fragments are removed, and the ammonia is fed back into the reactor. The hydrazine is further decontaminated and stored.

Calculations indicate that a yield of one molecule of hydrazine per 100 ev of fission fragment energy deposited in the process fluid is the breakeven point for an economical production plant. Aerojet states that its in-pile experiments have exceeded this yield.

X-15 Bulkheads Pressure-Sealed by Film Adhesive

A thermosetting elastomer phenolic film adhesive is used in the X-15 to seal segmented bulkheads in the liquid ammonia storage tank. The 10-mil-thick AF-30 film adhesive, developed by Minnesota Mining & Manufacturing Co., 900 Bush Ave., St. Paul 6, Minn., is reportedly effective from —67 to 300 deg F.

Designed for metal-to-metal bonding and sealing, the AF-30 has shear strengths of over 4000 psi at 70 deg F and of over 1650 psi at 300 deg F. It is said to remain flexible and resistant to such corrosive media as ozone, acids, water, jet fuels, and ammonia.

The X-15 liquid ammonia tank has Inconel and aluminum bulkheads. A thin, even coat of primer is applied to all areas to be sealed. Then, while the primer is still slightly tacky, the AF-30 adhesive film is positioned on the Inconel surface. A revolving punch is used to cut out fastener holes. An 0.005-0.01-in. overlap is left around each hole so that the film adhesive can flow along the sides of the inserted fastener to seal the joint completely. The adhesive backup liner is removed, the aluminum bulkhead is mated to the Inconel surface, and the assembly is then riveted. **83**

Vertical Solid-Propellant Mixer Is Said To Be Faster

The new vertical "Regal" mixer, The J. H. Day Co., 4932 Beech St., Cincinnati 12, Ohio, claims, processes solid propellants faster, more efficiently, and safer than any of its predecessors. Interchangeable mixing bowls cut idle time during loading and unloading. While the Regal mixes one batch, another is loaded into or unloaded from a second bowl. The mixing bowls are either caster or trolley-mounted depending upon the size of Regal.

Three vertical agitators overlap and intermesh to produce the intense shearing, tearing, and kneading actions necessary for highly accurate product dispersions. A four-wing agitator rotates in the center area of the mixing bowl; orbiting around it and rotating at twice its speed are two two-wing agitators. The agitator blades are helical, so that the mix is constantly moved from the top to the bottom of the mixing bowl and no stratification can occur.

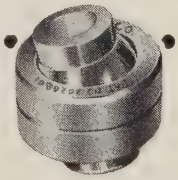
For details of equipment listed in this section, write in item number on Reader-Service Card

SOUTHWEST "Monoball"® SELF-ALIGNING BEARINGS

ROD END TYPES

PATENTED U.S.A.
All World Rights Reserved

PLAIN TYPES



CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Alloy Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Steel Ball	For types operating under normal loads with minimum friction requirements.
4	"Dyflon"® Plastic Alloy Inserts. CRES Ball and Race. Chrome Alloy Steels.	For types operating under rotational, high radial loads and long cycle life where lubrication is impossible.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Our engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. Write for Engineering Manual No. 551. Address Dept. S/A 61.

SOUTHWEST PRODUCTS CO.
1705 SO. MOUNTAIN AVE., MONROVIA, CALIFORNIA

No. 48 on Reader Service Card

Response-ability!

PLUS REDUCED SIZE AND WEIGHT

ACTUAL SIZE
(versus ordinary commercial servo-type motor)

EAD 60 CYCLE MINIATURE SIZE 15 SERVOMOTORS

Design *instant response* into your recording instruments and, at the same time, miniaturize your "package" with substantial cost-reductions. EAD 60 cycle, size 15 miniature servomotors are engineered for RESPONSE-*ability*... the ability to produce rapid acceleration and reversing without over-power and over-size.

These 60 cycle, size 15 servomotors, now available for commercial applications, have the same precision RESPONSE-*ability* as EAD's military versions... your assurance of high performance and reliability.

TYPICAL PERFORMANCE DATA

MODEL	S2HBZ7-*	S2HAX7-*
Voltage	115 volts	115 volts
Frequency	60 cycles	60 cycles
Stall Power/Phase	6.0 watts	6.0 watts
Stall Current/Phase	70 MA	70 MA
Time Constant	.0052 Sec.	.00915 Sec.
Reversing Time	.0089 Sec.	.0155 Sec.
Rotor Inertia	4.0 gm cm²	3.3 gm cm²
No Load Speed	1500 RPM	3000 RPM
Stall Torque	1.7 oz-in	1.6 oz-in

*Basic models. Mechanical modifications available to customer requirements.

If *your* responsibility is improved recorder design, look first to EAD for the servomotor line that meets all your RESPONSE-*ability* requirements. Call your nearest EAD representative or write about your specific needs.

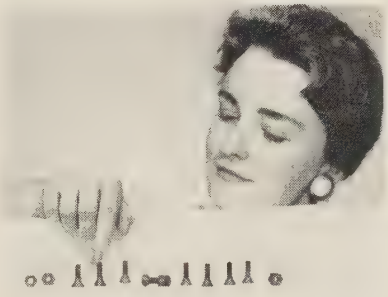
Rotation Is A Science At
EASTERN AIR DEVICES, Inc.
A SUBSIDIARY OF NORBUTE CORPORATION
365 Central Ave., Dover, New Hampshire

No. 49 on Reader Service Card

Lubricants cannot contaminate the mix, since there are no bearings or stuffing boxes in the product zone. Thermocouples in the mixing bowls detect any dangerous temperature rises.

Mixing can be done either under pressure or in a vacuum. The mixing bowls are jacketed for cooling or heating to any predetermined temperature. All bearings are anti-friction types and run in oil baths. The driving mechanisms are shear-pin-protected. **82**

Fiberglass Nuts, Screws Highly Heat-Resistant



Fiberglass ¼-20 screws and nuts have been successfully molded and machined by Pam-Pro Plastics, Menlo Park, Calif. They are made of Trevarno-F-120, a Coast Manufacturing & Supply Co. glass fabric preimpregnated with phenolic resin. Trevarno F-120 is specially modified for high-temperature strength and is designed for low-pressure molding as well as high-pressure laminating.

Fiberglass is used because of its low heat conductivity and because it vaporizes at a steady rate when exposed to extreme temperatures and so tends to cool itself. The new fiberglass screws and nuts are heat-resistant. The threads are said to be of a strength uncommon in highly abrasive materials. **81**

equipment in brief

SILICONE POTTING for electronic assemblies

A clear silicone potting and embedding compound that provides mechanical and dielectric protection for electronic components and assemblies has been announced by **Silicone Products, General Electric Co., Dept. S/A, Waterford, N. Y.** Called LTV (low temperature vulcanizing), 602 it cures at 70 deg to 80 deg C. to a flexible, resilient solid.

The compound is said to provide excellent protection against shock, vibration, moisture, ozone and corona and other environmental hazards of the space age.

No. 175 on Reader Service Card

CLOSED CELL SPONGE features small cell size

Closed cell Viton and Fluorel Sponge, said to feature extremely small and uniform cell size, are announced by **Industrial Electronic Rubber Co., Dept. S/A, 31945 Aurora Rd., Solon 39, Ohio.** The foam product has all the chemical resistance, says the maker, of the standard Fluorinated polymer from which it is made.

The foamed version has approximately one-fourth the density of the solid product; this permits a wide range of compressibility in such applications as gaskets and mountings.

No. 176 on Reader Service Card

SPECIAL CABLE CONSTRUCTIONS

- Solid or stranded copper conductors; tinned—silver plated
- Teflon or silicone rubber insulation
- Twisted pairs; multiple conductors
- Jackets of Nylon, Teflon, fiberglass or silicone rubber
- Braided metal shielding

These and many other special cable constructions are available to you from the Markel Line of Excellence. Phone, write or wire your specs for a Markel quotation.

L. FRANK MARKEL & SONS

SOURCE for EXCELLENCE in *Insulating Tubings, Sleevings, and Lead Wire*

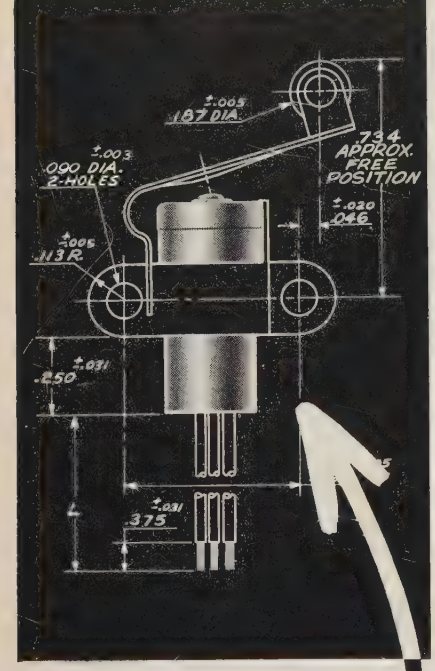
NORRISTOWN, PENNSYLVANIA

No. 91 on Reader Service Card

WHERE RELIABILITY IS PRIME REQUISITE . . .

KLIXON®

CUSTOM-DESIGNED SWITCH PACKAGES!



Basic AT 1-1 (ACTUAL SIZE) as mounted in stage separation switch assembly. Rating: 3 to 5 amps resistive; 115 vac/28 vdc

The smallest, HERMETICALLY SEALED, precision-calibrated, snap-acting switch ever designed is the nucleus of custom-designs like the missile stage separation switch assembly shown. Other KLIXON switch packages have been specified for guidance, ground support, firing circuits, communications equipment and similar critical functions . . . in the Polaris, Pershing, Minuteman, Redstone, Discoverer, Samos, Midas and Centaur Missiles . . . where reliability is prime requisite!

Design engineers save vital time by ordering complete switch packages . . . parts numbers are assigned at once for use in parts list. Customer's exact design needs are met with unique mounting configurations, connectors, leads, actuators, ganging of basic units, potting, etc.

SPECIFICATIONS of KLIXON Type AT1-1

Actuating force	12 ±8 ozs.
Release force	1 oz. min.
Pretravel	.005" approx.
Overtravel	.003" min.
Movement differential	.002" approx.
Minimum life cycles	10,000
Weight	.036 ozs.
Amb. temp. range	65°F to 275°F
Contact separation	.010" approx.
Vibration resistance	40 G's
Shock resistance	100 G's

Complete specifications and details of mounting options and activators upon request. Request details today!

METALS & CONTROLS INC.
3707 FOREST STREET • ATTLEBORO, MASS.
A CORPORATE DIVISION OF
TEXAS INSTRUMENTS
INCORPORATED

No. 92 on Reader Service Card

PORTABLE UNIT is inert gas room

This vacuum dry box is a portable and complete inert gas room. It provides for working in a rare gas, for inert atmosphere welding, for poisonous substances, or with explosive and hazardous materials, according to **Controlled Atmosphere Enclosures Mfg. Co., Dept. S/A, P. O. Box 3693, Jacksonville 6, Fla.** The box can be evacuated to 50 microns with a leak rate of 1 micron per minute.

It is equipped with low-permeability Butyl gloves and evacuable glove ports, air-lock fluorescent lamp, welding or "safety" windows.

No. 181 on Reader Service Card

BEARING STEELS for high temperatures

A family of bearing steels said to offer improved properties over regular 440 C stainless steel is announced by **Latrobe Steel Co., Dept. S/A, Latrobe, Pa.** They are said to exhibit improved hot hardness properties and better resistance to wear, corrosion, and oxidation.

The Lesco BG 41 is said to be basically a replacement of 2 per cent chromium in the 440 C analysis with 4 per cent molybdenum. The Lesco BG 42 and 43 consist of 1 per cent and 2 per cent vanadium.

No. 182 on Reader Service Card

FIBER GLASS CLOTH for contour surfaces

This fiber glass cloth is designed for laminating deep, sharp contour surfaces. It is .0283 in. thick and will form into and retain its position over a very sharp radius and deeply recessed area, according to **Rezolin, Inc., Dept. S/A, 1651 18 St., Santa Monica, Calif.** It is designated Drapeze #391.

Applications include close tolerance plastic tooling, patterns and equipment, boat construction, and critical reinforced plastic parts.

No. 183 on Reader Service Card

HIGH SPEED STEEL adds to tool life

A grade of high speed steel, designated Rex 49, which is designed to provide greatly increased tool life in machining hard-to-cut metals, has been developed by the **Crucible Steel Co. of America, Dept. S/A, Pittsburgh 22, Pa.** It is designed to cut such materials as highly alloyed steels at high hardness levels, stainless steels, super alloys and titanium.

The steel can be heat treated to Rockwell 'C' 67 to 69. Its use permits increases in speed, feed or depth of cut, it was stated.

No. 184 on Reader Service Card

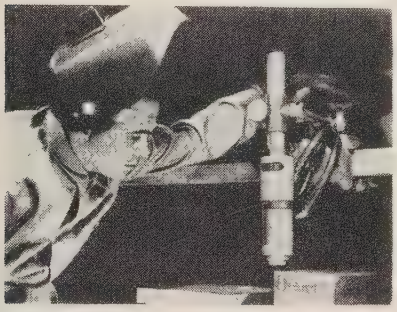
STAKE NUTS save space and weight

These floating and non-floating stake nuts are said to save up to one-third hardware weight, and require less space in staking operations. Minimum thickness requirement for the floating type is .040 in. and for the non-floating, .030 in., says **Kaylock Div., Kaynar Mfg. Co., Dept. S/A, Box 2001 Terminal Annex, Los Angeles 54, Calif.** Push-out, torque-out and thread-locking features are said to exceed requirements of MIL-N-25027.

The design feature at the base of the nut provides a positive stop when driven into the parent material.

No. 185 on Reader Service Card

PLASMA CUTTING TORCH for use on any metal



This metal cutting torch makes use of the principle of ultra-high temperature plasma. It cuts steel, stainless, aluminum, copper, cast iron or any other metal up to 4 in. thick or beyond, according to **Thermal Dynamics Corp., Dept. S/A, Lebanon, N. H.** Using argon, nitrogen and hydrogen mixtures, and operating with dc power, the cutter fits any standard carriage or pantograph.

Controls for gas mixtures, gas velocities and electric power permit quick adjustment for metal thickness and for cutting speeds from one inch to hundreds of inches per minute. Typical speeds for mild steel, stainless, aluminum, etc., are 200 in. per minute.

No. 186 on Reader Service Card

SILICA FIBER CLOTH for high temperatures

This Refrasil-vitreous silica fiber cloth in the field of preformed electrical insulation components provides for high temperature materials needed in areas of radiation. Physical properties and insulating values of the product are not adversely affected in 1800 deg F., according to **Stevens Products, Inc., Dept. S/A, 86-88 Main St., E. Orange, N.J.** Thermal and mechanical properties are said to be stable in exposure to radiation.

No. 187 on Reader Service Card

Rockbestos Firezone Aerospace Wire Resists Jet Engine Heat in B-52

Rockbestos Firezone Type 101 Aerospace Wire is used for power and control circuits in the B-52 jet bomber, renowned for its high performance and dependability.

Dependability is designed into Rockbestos Aerospace wire too. In jet aircraft Rockbestos Wire resists the high temperatures around engine and afterburner sections. It is also used for high impedance circuits in guided missiles.

Standard Rockbestos Aerospace wires cover a temperature range from 257°F to 750°F. Many special wires have been produced to operate at even higher temperatures. In addition to high temperature aerospace wire, Rockbestos supplies hook-up wire, coaxial cable, and ground support cable.

For complete information on Rockbestos Aerospace Wire & Cable write for Bulletin.

ROCKBESTOS WIRE & CABLE CO.
DIVISION OF **CERRO CORPORATION**
MAIN OFFICE AND FACTORY: Nicoll and Canner Streets, New Haven, Conn.

No. 93 on Reader Service Card

STEERING GEAR FOR OUTER SPACE:

BENDIX THRUST VECTOR CONTROL SYSTEMS

SECONDARY INJECTION: Newest way to "call the turns" in outer space. Bendix is now heavily engaged in research and development work on systems to steer Polaris and other missiles and spacecraft. This work involves the study and mechanization of means for deflecting the rocket motor jet by means of liquid and gas injection.

MOVABLE NOZZLES: Proved Bendix system, embodied in the Minuteman program. Responding to signals from the vehicle's "message center," nozzles move to change direction of the thrust, and course, of the rocket. Test firings have proved this system's reliability, time after time. The Bendix system saves 40% in weight compared with previous test systems, and has low actuation torque requirements.

Qualified contractors are invited to write for further information. Write: Bendix Products Division—Aviation, South Bend 20, Indiana.

Bendix PRODUCTS DIVISION South Bend, IND.

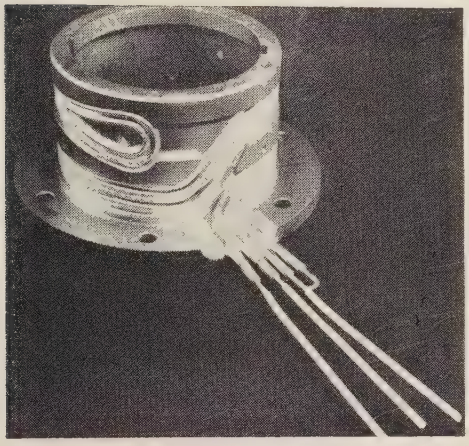
THE Bendix CORPORATION

No. 94 on Reader Service Card

equipment preview

II—Accessory Equipment

HEATERS FOR CRYOGENIC BEARINGS IN TITAN LOX PUMP

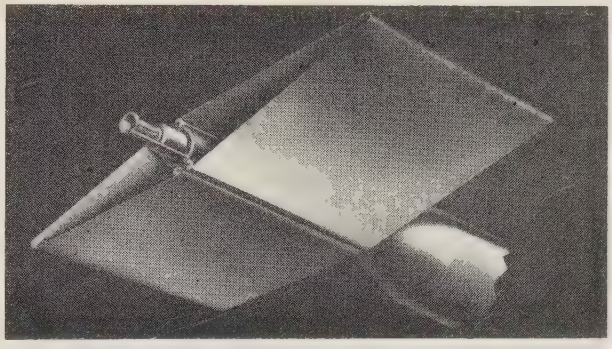


A special heater has been developed by General Electric Industrial Heating Dept., Schenectady 5, N. Y., to supply heat to a bearing in the lox-pump gear drive of the Titan missile. Because of the extremely low temperature of the lox, heat is needed to keep the lubricants in the bearing from freezing.

Developed for Aerojet-General, the heaters use 0.085-in.-diameter, 304 stainless hypodermic-needle tubing as sheathing, with the resistance wire encased in a "rock-like" insulation. They are precision-formed to fit into machined grooves in the bearing sleeve. Two heaters are used on each bearing. They have an output of 40 W per square inch of heater surface.

Series-parallel electric combinations let the heaters operate on either 115 or 28 V. The ambient temperature limits are —300 and 750 deg F. Special end terminations are used to increase the electric creepage distance. The ends are hermetically sealed. This design produces a shock- and vibration-resistant unit that withstands a 600-V high-potential test and has a hot insulation resistance in excess of one megohm.

Moving-Belt Radiator Heat for Nuclear Spacecraft



North American Aviation's Rocketdyne Div. has designed a unique moving belt heat radiator for earth satellites and interplanetary vehicles and has demonstrated a working model.

The moving belt radiator design is an outgrowth of over four years of research. The company says it provides a practical means for removing heat generated in nuclear-powered space vehicles and is two-thirds lighter than proposed tube and fin radiators. It can also withstand bombardment and penetration by meteroids.

Twin belts extend from the waste heat rejection core, one on each side. They move continually, picking up heat from the core's outer surface and radiating it from the surfaces of the belts as they rotate in space.

At launch, the belt would be wrapped around the generating assembly and enclosed in an aerodynamic shield, which would be jettisoned after the vehicle reached its orbital flight path. The belt then unfolds automatically and the radiator carriage begins to revolve about the power conversion capsule at a predetermined speed.

The whirling speed of the belt assembly can be preset to maintain a constant temperature in the radiation system under any power level of operation desired.

Because of its relatively light weight, the advantages of the moving belt radiator increase as the power of the space vehicle increases. However, it can also be used effectively for a relatively low-powered unit such as Snap 9.

A specific design study of a 300 kw nuclear vehicle showed that the radiator would be approximately 80 ft long and 800 lb as compared to 1800 lb for a tube and fin radiator for the same vehicle.

BAR-X® SEALS EVERYTHING

AT TEMPERATURES FROM −400° F TO +1500° F!

ANY FLUID—GAS—FUELS—WATER—LIQUID METALS—CRYOGENIC FLUIDS—CORROSIVE FLUIDS
ANY SYSTEM—HYDRAULIC—PNEUMATIC—VACUUM—CRYOGENIC—NUCLEAR

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HOT GAS SERVOS

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VACUUM SYSTEMS

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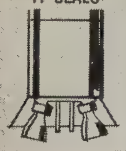
YOURS

IT SEALS

PUMPS

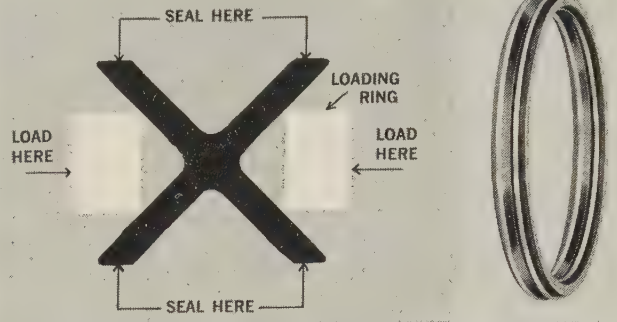
IT SEALS

HYDRAULIC ACTUATORS

IT SEALS

ROCKET ENGINES

IT SEALS

NUCLEAR ENVIRONMENTS



DUAL-SEAL REDUNDANT DESIGN
DYNAMIC & STATIC APPLICATIONS

BAR-X-SIZES:
½" TO 3" STANDARD
3" TO 12" SPECIAL

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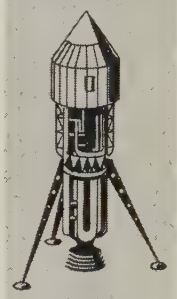
SPACE ENVIRONMENTS

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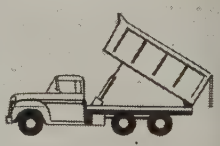
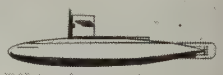
INFINITE STORAGE LIFE

NO CATASTROPHIC FAILURES
INFINITE STORAGE LIFE
UNPRECEDENTED SERVICE LIFE

Eliminates critical downtime ■ Very high and very low pressure ■ Easy, foolproof installation (not a mechanism) ■ All-metal—non-contaminating ■ Stable, symmetrical design

WRITE TODAY FOR THE FULL STORY! **SALES ENGINEERS IN PRINCIPAL CITIES.**

IT SEALS

NO DOWNTIME FROM SEAL FAILURE

IT SEALS

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Wiggins

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TWX 1403U, Phone AN 9-0181

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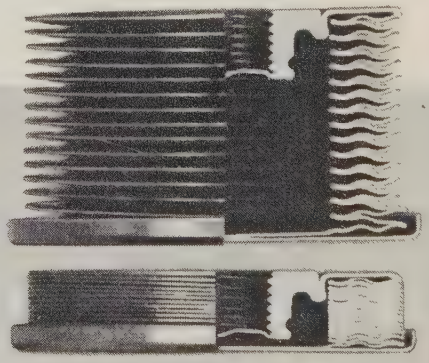
WELDED DIAPHRAGM BELLOWS By METAL BELLOWS CORP.

111-1



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PRATT & WHITNEY AIRCRAFT — DEPENDABLE ENGINES

Used by Leading Manufacturers of Guidance and Propulsion Systems In Aero-Space Applications

Where extreme accuracy, reliability and consistent performance are specifications . . . you can depend on the pioneers and leaders in welded metal diaphragm bellows research, engineering and manufacturing to deliver the results.

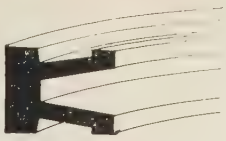
Design and manufacturing services are available in full depth from our plants on the east and west coasts.

METAL Bellows CORPORATION

104 MICA LANE, WELLESLEY HILLS 82, MASSACHUSETTS • Pacific Division: 209710 Knapp Street, Chatsworth, (L.A.) California

No. 96 on Reader Service Card

Metallic Static Face Seals for up to 2000 deg F and 20,000 psi



Designed specifically to meet the high-pressure and extreme-temperature requirements of missile and aircraft systems, its new line of metallic face seals can be used for static sealing problems that elastomers cannot solve, says Haskel Seal Div., Haskel Engineering & Supply Co., 1236 S. Central Ave., Glendale 4, Calif. The HS Series seals, providing zero leakage at temperatures from —450 to 2000 deg F and at pressures up to 20,000 psi, are made in age-hardened Inconel X and A-286, 17-4PH H1150, 7056-T-6 aluminum, heat-treated 18-8 Cres, and annealed tantalum. Most of these materials are available with platings of silver, gold, indium, Teflon, Kel-F, copper, etc. The seals are re-usable and light, have no storage or aging problems, and are offered in a wide range of sizes.

The HS seals are lapped to provide flat and smooth sealing faces. They have an integral spacer, so that no close control of groove depth is necessary to install a seal, it is merely indexed to one mating surface and the opposing surface is then brought against the seal. High torque loading is normally not required. The design strength necessary to contain unit pressures usually provides enough force to seat the seal for proper performance. **85**

Equipment Cooler Uses Shock-Compressed Ram Air

Direct air-cooling of equipment in supersonic aircraft is possible despite the considerable rise in air temperature caused due to shock compression, says The Hallicrafters Co., 4401 W. 5th Ave., Chicago 24, Ill. In fact, shock compression supplies the only power required to operate the company's Hilsch vortex tube "refrigerator."

The equipment to be cooled will be housed in a pod attached to the aircraft. An inlet like a ramjet's admits shock-compressed air to the Hilsch tube. The air enters tangentially and is spiraled into a vortex. An orifice bleeds off the low-energy (low-temperature) air molecules for equipment cooling; the hotter, high-energy particles are exhausted overboard. A valve in the hot line controls the relative air flows, regulating the air temperature downstream of the orifice.

At an ambient of 60 deg F, the stagnated Hilsch-tube inlet air temperature of an aircraft flying at Mach 2 at sea level is 474 deg F. Ideally, one ppm of 131-deg-F air can be extracted from every 1.54 ppm of air entering at 474 deg F. Even at considerably less than ideal performance, Hallicrafters believes the simplicity of the vortex tube promises great savings in weight, space, power, and cost over mechanical refrigeration systems. **84**

equipment in brief

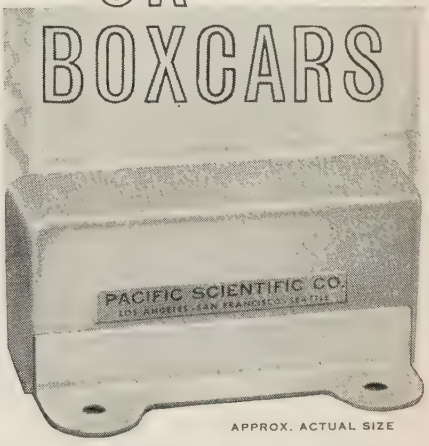
CANNED PUMP for thrust balance

A line of leak-proof canned pumps having automatic thrust balance design has been announced by **Chempump Div., Fostoria Corp., Dept. S/A, Huntingdon Valley, Pa.** Motor life of the series G units is said to have been extended by an oil filled stator cavity that dissipates heat from motor windings.

The manufacturer says that the pumps practically eliminate the two service points, bearing and motor windings, and that larger bearings and bearing surfaces provide longer life and low maintenance burden.

No. 177 on Reader Service Card

FOR "BIRDS" OR BOXCARS



APPROX. ACTUAL SIZE

New PACIFIC "G" SENSING INERTIA SWITCH

...provides high performance

...reliable acceleration switching!

Pacific's new inertia switch is readily adaptable to meet a variety of "G" sensing uses from missiles to freight cars. It permits a wide variation in performance and range with only a minimum of engineering and development to meet specific requirements. A unique switching action provides positive "make or break" action of the electrical contacts at the "G" setting regardless of environmental conditions.

For information on Pacific inertia switch designed to your own requirements...or on a standard unit, WRITE TODAY. The engineering skill and creative ability of Pacific Scientific are at your service.

Write for current engineering data sheets—

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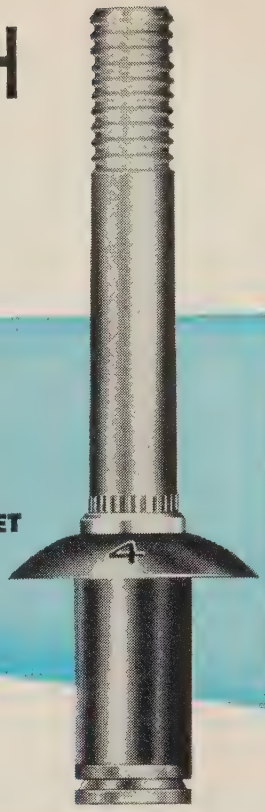
No. 97 on Reader Service Card

SOLID RIVET STRENGTH WITH BLIND RIVETS

CHERRYLOCK RIVETS for Your Difficult Solid Rivet Applications



BULBED CHERRYLOCK

ONLY THE BULBED CHERRYLOCK RIVET GIVES YOU ALL THESE ADVANTAGES

Mechanically Locked Stem • Flush Fracture (No Stem Trimming) • Positive Clamp-Up • Full Grip Range • Complete Hole Fill • Minimum Blind Side Clearance • Positive Visual Inspection (Grip Length Marked on Head)

Ideal for Thin Sheet and Double-Dimple Applications—extremely large blind head

The Bulbed Cherrylock* offers a blind rivet that installs and performs like a solid rivet. Bulbed Cherrylock Rivets will qualify where you are now using solid rivets, offering higher joint strength with greatly increased joint reliability under critical loading conditions—fatigue, shake and sonic vibration.

Now Cherrylock rivets give you a blind rivet that can be used in expensive forgings as well as for joining and attaching sheets and components.

For technical data on Cherrylock Rivets, write Cherry Rivet Division, Townsend Company, Box 2157P, Santa Ana, California.

* Patent Pending

CHERRY RIVET DIVISION

SANTA ANA, CALIFORNIA

Townsend Company

ESTABLISHED 1816 • BEAVER FALLS, PA.

In Canada: Parmenter & Bulloch Manufacturing Company, Limited, Gananoque, Ontario

SPEED CHANGER has magnetic clutch

An electromagnetic speed changer with a self-contained magnetic clutch has been introduced by **Orbit Instrument Corp., Dept. S/A, 131 Eileen Way, Syosset, N.Y.** The unit operates on 115 volts DC at 5 watts, and the input shaft is concentric to 0.0015 in. with the output shaft.

Two speed ratios are available—1 to 1 when energized, and 9 to 1 step down when de-energized. At 1 to 1, it transmits 70 in.-oz minimum at the output shaft; at 9 to 1, 30 in.-oz minimum. Maximum torque transmitted is limited to 85 in.-oz by means of the built-in slip clutch.

No. 188 on Reader Service Card

SEQUENCE TIMER for missile use

Model 4-23 is a miniature adjustable sequence timer designed specifically for rocket, missile, and satellite use. The timer features micro adjustable cams that can be set to within 0.1 percent of the total period. The adjustable time span is 1 second to 45 minutes. The timer provides switch closures during and after powered flight, and uses less than 70 milliamps.

Developed by **Acton Laboratories, Inc., Dept. S/A, 533 Main St., Acton, Mass.**, the timer is designed for long-lasting, rugged use. The timer features include: drive, gear housing, cam shaft, and switching, mounted in a solid frame; nylon to brass worm and gear combinations; quick-set cams; heat dissipation through the solid frame; wired, ready to use; and completely enclosed.

No. 189 on Reader Service Card

BALL BEARING has low torque retainer

Available in sizes R2, R3, and R4, the MPB R series of ball bearings uses a lightweight, stainless steel retainer that reportedly reduces the internal friction to a minimum. The two sections of the retainer are crimped together so that they are able to move only slightly, relative to each other, thereby greatly reducing the starting torque.

The R series bearings are available with flanged outer rings for simple mounting, single or double shields, and as either duplexed or preloaded pairs, says **Miniature Precision Bearings, Inc., Dept. S/A, Keene, N.H.** For high speed applications, R series bearings are made with one-piece paper base phenolic retainer. Outer diameters range from 0.375 in. to 0.625 in., with bores from 0.125 in. to 0.250 in.

No. 190 on Reader Service Card

No. 98 on Reader Service Card

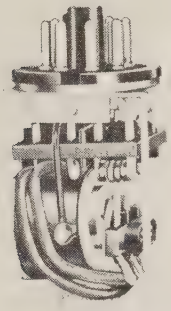
BRAKE-CLUTCH UNITS are electrically operated

These brake-cluth components, sizes 8 and 11, are electrically operated and are intended for servo applications, including motor-potentiometer, motorgearhead, or other assemblies requiring fast stopping or starting, or requiring engagement or disengagement from continuously running driving sources. The size 11 unit weighs less than 5 oz and is 1.839 in. in length, exclusive of shafts, according to **Bowmar Instrument Corp., Dept. S/A, 8000 Bluffton Rd., Fort Wayne, Ind.** Input and output shafts are coaxial, the output shaft in center and the input a concentric sleeve-like flange.

Minimum brake or clutch torque is 16 inch ounces, response time is 23 milliseconds, and it is designed for 28 vdc operation. The size 8 unit is 1.530 in. long and weighs 2.5 oz. Torque is 8 in.-oz minimum at 12 milliseconds.

No. 191 on Reader Service Ca d

PLUG-IN RELAY has built-in lamp



A miniature neon lamp, connected across the coil terminals of a 1210-N plug-in relay, lights when the coil is energized. If the lamp does not glow with the coil energized, a circuit fault is indicated. Principal advantage of the light is that it eliminates the use of a circuit tester.

Guardian Electric Manufacturing Co., Dept. S/A, 1550 West Carroll Ave., Chicago 7, Ill., reports that the unit is now being used in relay banks, mass relay installations, and wherever relays are visible at intermediate switching points. The relay is available with 8-pin octal plug for DPDT and 11-pin for 3 PDT. Contacts are rated 8 amps at 115 volts, 60 cps, non-inductive load.

No. 192 on Reader Service Card

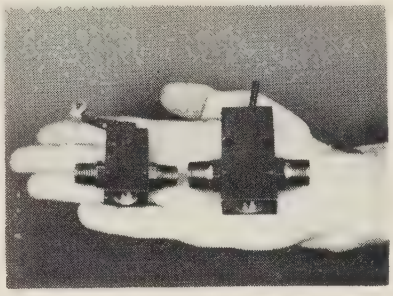
SERVO AMPLIFIER has own power

Model A425 servo amplifier has been designed to provide full power to servo motors, up to size 18. Available from **Westamp, Inc., Dept. S/A, 11277 Massachusetts Ave., Los Angeles 25, Calif.,** the amplifier features its own power supply and is ready to connect to commercial power sources.

Specifications are: voltage gain—2000 (typical); gain stability—20 per cent; output voltage—40 volts rms; output power—9.5 watts; and temperature range—0 to +150 deg F or —55 to +71 deg C.

No. 193 on Reader Service Card

MICRO VALVES for pressures to 100 psi



These micro valves are said to feature male pipe connections which turn, permitting installation without unions. The miniature units are for operating pressures up to 100 psi, according to **Instruments, Inc., Dept. S/A, P.O. Box 556, Tulsa, Okla.** They have fast, positive snap-action.

They are available in a variety of orifice sizes, materials, and types of operators. Two or more valves may be manifolded for multiple operations.

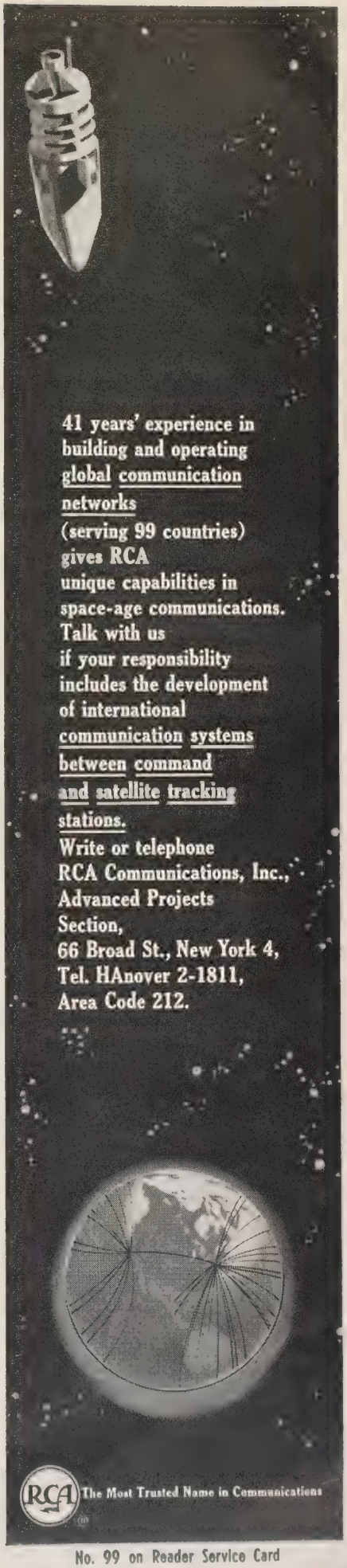
No. 194 on Reader Service Card

FILTER ASSEMBLY for fluid line systems

This light weight, miniature filter assembly is for fluid line systems. It offers universal, in-line applications wherever caustic and/or corrosive liquids or gases are being handled, says **Dozier-Eastman & Co., Dept. S/A, 400 Silver Lake Blvd., Los Angeles 26, Calif.** It is satisfactory for use with nearly all elements and blends, including food products.

It has been in service, the maker says, with gases to 2250 psi, and will withstand temperature extremes from —350 deg F. to +500 deg F. It is 1⅛ in. square and about 2 in. overall in length. The screen offers maximum flow and provides ½ sq in. of filter surface, of which about ½ is open flow area.

No. 195 on Reader Service Card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No. 100 on Reader Service Card

FREQUENCY STANDARD for missile applications

Designed primarily for missile or other airborne applications, a 400 cps crystal frequency standard featuring high stability under rugged environmental conditions and varying input voltages is announced by the **Electronics Div., Dept. S/A, Bulova Watch Co., Inc., 40-01 61st St., Woodside 77, N. Y.** The hermetically sealed can is 2 by 2 by 4¼ inches.

Its stability is maintained throughout temperature ranges of —20 to 71 deg. C. at vibration levels of 5 to 2000 cps at 15 Gs and up to 100 Gs shock. Input is 28 volts dc (25-29vdc) 1 V rms ripple. The output is a square wave 2 volts peak-to-peak minimum into a 1 kilohm load.

No. 196 on Reader Service Card

LINEAR ACTUATOR uses dc motor

This linear actuator uses a dc motor to operate a precision ball screw and provides 500 lb over a 6-in. stroke. Rate of travel is fixed at inches per minute, according to **Globe Industries, Inc., Dept. S/A, 1784 Stanley Ave., Dayton 4, Ohio.** Maximum allowable tension or compression load is 2500 lb.

Temperature range is —65 deg to 300 deg F. The unit operates on 27 to 100 cdc; universal ac/dc operation is available. The actuator measures 14 7/16 inches long by 1¾ inches wide by 3¾ inches. Weight is 3 lb, 14 oz.

No. 197 on Reader Service Card

BALL BEARING SCREW has freewheeling stops

This ball bearing screw design makes it possible to limit the travel of the nut at preset positions while the screw continues to rotate. A stop in the screw at each end of the desired nut travel and a simple freewheeling device do the job, says the **Saginaw Steering Gear Div., General Motors Corp., Dept. S/A, Saginaw, Mich.** Mechanical efficiencies are reported to range from 90 to 95 per cent.

Units have the same load-carrying capacities as conventional screws of the same size. One design, with a pitch diameter of 0.631 in., was tested for 45,000 cycles under a 500-lb load.

No. 198 on Reader Service Card

SHUT-OFF VALVE is solenoid operated

This solenoid operated shut-off valve is said to close the gap of high pressure gas and hydraulic sealing to near zero leakage. It is intended for ground support equipment and industrial applications, according to **Pneu-Draulics, Inc., Dept. S/A, 8961 Central Ave., Monclair, Calif.,** and can be normally open or normally closed.

The unit is available in ¼ in. and ⅜ in. ports. Overall valve dimension is 2.75 in. square, 7.25 in. high. It operates on 110 v ac, 60 cycle to 3000 psi.

No. 199 on Reader Service Card

RATE GYRO has uniform response

It is reported that the series 7601 Talisman sub-miniature rate gyro offers greatly improved damping, reduces power requirements, and eliminates the external choke. According to **Lear, Inc., Dept. S/A, 3171 S. Bundy Drive, Santa Monica, Calif.,** damping is entirely disassociated from the volumetric compensator so that changes in density do not affect damping performance. Because damping is held from 0.5 to 0.9 times critical over a temperature range of —54 to +84 deg C, it is claimed that the response time remains uniform over the temperature range. Uniformly low natural frequency oscillation of the gimbal assures fast gyro recovery, even during rapid movement.

Maximum power consumption is said to be 1½ watts. The unit operates on 26 volts, 400 cps, and is available in single, two, or three phase versions.

No. 200 on Reader Service Card

SHUT-OFF COUPLING has 2-way check valve

This series G, double shut-off, quick coupling has a two-way check valve that stops flow from both lines when making or breaking connections. Available in steel or brass from **Breco Div., Perfecting Service Co., Dept. S/A, Charlotte, N.C.,** the unit incorporates one-hand "pushomatic" locking action to form a positive, high pressure, leakproof connection, says the company.

The locking mechanism is automatic, requiring no twisting or turning. The large flow chamber permits maximum flow of fluids. Swivel action prevents hose tangling and kinking, and permits the hose to hang in a natural curve for easier handling. The couplings are available in ¼, ⅜, ½, or ¾ in. sizes for working pressures up to 8000 psi.

No. 201 on Reader Service Card

TACHOMETER
has high voltage output

This 45 v/1000 rpm tachometer, model SU-7802-1, has an overall body length of 3½ in. High output is owing to an increased armature length, according to **Servo-Tek Products Co., Dept. S/A, 1086 Goffle Rd., Hawthorne, N. J.** The design increases the voltage output while keeping inertia at a minimum.

The unit is supplied with a stainless steel shaft having a diameter of 3/16 inch and a convenient flange for ease of mounting.

No. 202 on Reader Service Card

LATCHING RELAYS
for dry circuits

This voltage-sensitive, micro-miniature latching relay is for dry-circuit and high-level switching. Model 76GB-N is dual-coil, balanced-armature designed for fast operating, dry circuit, high level switching relays to perform in a small, hermetically sealed enclosure, says **Iron Fireman Mfg. Co., Electronics Div., Dept. S/A, 2838 S. E. 9th Ave., Portland 2, Ore.** It will withstand vibrations of 30 g to 2000 cps and shock of 100 g.

Normal operating power is 90 milliwatts and the contacts are rated at 10 uamp resistance at 10 millivolts DC or AC for dry circuit and two amps resistive at 28 V DC or 115 V AC for high level.

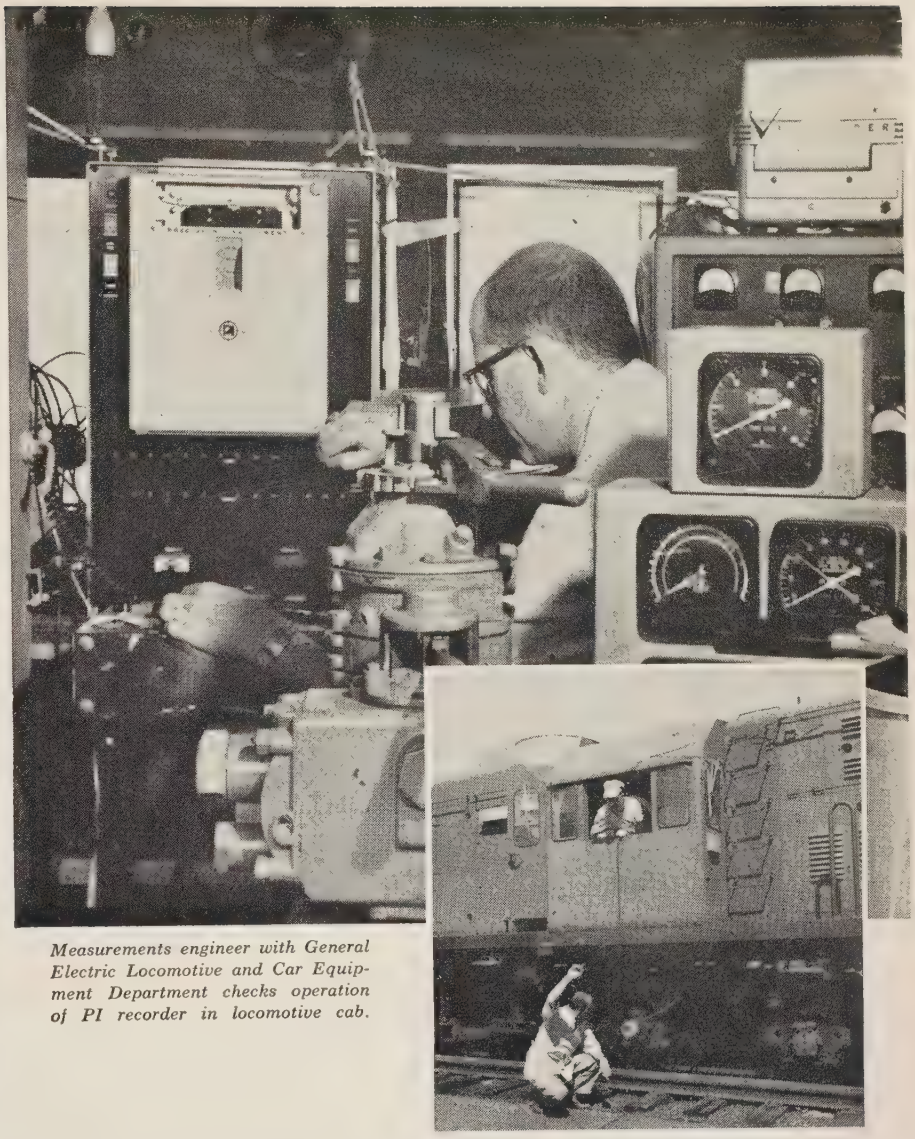
No. 203 on Reader Service Card

PILOT AIR SUPPLY
for emergency uses

This compressed emergency air supply, containing 3000 lb per square inch of air, weighs 3.50 lb and is intended to be strapped to the pilot. The bottle is forged from B-120VCA titanium, says **DK Mfg. Co., Dept. S/A, Chicago, Ill.** The bottle is 14 in. long, and 4⅜ inches o.d.

The chamber contains a helium atmosphere and is filled with air under pressure.

No. 204 on Reader Service Card

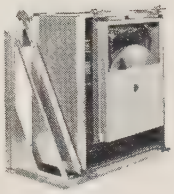


Measurements engineer with General Electric Locomotive and Car Equipment Department checks operation of PI recorder in locomotive cab.

PI Tape Recorder rides the rails– writes 14-track travel report

Even in the pitching, rolling cab of an 1800-horsepower diesel-electric locomotive, it's an easy task for a PI instrumentation magnetic tape recorder to gather data with laboratory accuracy. In special tests recently run by General Electric's Locomotive and Car Equipment Department, their PI 14-track tape recorder was used to measure such parameters as shaft torque, motor-mount movement, strain information, vibration, speed and motor current data.

Magnetic tape was chosen for the job because it permits automatic frequency analysis and analog computer processing of quasi-random data. Such data, when recorded by conventional oscillographic methods, may be extremely difficult and time consuming, if not impossible, to analyze.



Precision π Recorder shown in standard shock mounting

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*Drone Anti-Submarine Helicopter.

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No. 102 on Reader Service Card

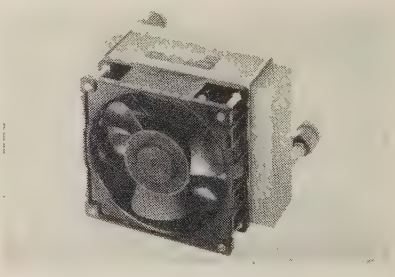
PUMP
is cooled by pumped fluid

This seal-less canned motor pump is lubricated and cooled by the pumped fluid. It is equipped with a welded stainless steel clad rotor and stator, allowing the pumped fluid to pass through the motor air gap, according to **J. C. Carter Co., Dept. S/A, 671 W. 17th St. Costa Mesa, Calif.** The motor is internally protected with a thermal overload switch.

The model 6222-15S, a 15 hp, single stage centrifugal pump, develops a 200 ft head at a flow rate of 230 gpm.

No. 205 on Reader Service Card

HEAT EXCHANGER
has internal fins



A unique arrangement of internal fins inside the core tubes of this heat exchanger is reported to boost heat transfer rate by 50 per cent over non-inner finned types. According to **Lytron, Inc., 42 Brookford St., Cambridge 40, Mass.,** this all-aluminum unit with matching fan offers high heat removal at a fraction of the space ordinarily required.

Hot oil returning from the electronic component is cooled by ambient air. With fluid temperature in the 80 deg C range, it will dissipate approximately 1000 watts of heat, says Lytron.

No. 206 on Reader Service Card

COMPACT POWER UNITS
for missile uses

These auxiliary power units are for all three stages of the Minuteman missile and feature a highly integrated design. A particular feature is that the hydraulic pump is completely immersed in the reservoir hydraulic fluid, according to **Vickers, Inc., Sperry Rand Corp., Dept. S/A, Detroit 32, Mich.** The packages include a 24 v dc motor with radio noise filters, fixed angle variable delivery hydraulic pump, self-pressurizing bellows type hydraulic reservoir, 5-micron hydraulic filter, check valve, pressure transducer, and pressure switch are interconnected through internal passages in a single manifold located between the motor and pump.

No. 207 on Reader Service Card

KEARFOTT SIZE 5 COMPONENTS

FOR SERVO SYSTEM MINIATURIZATION

SHOWN ACTUAL SIZE

A complete family of Size 5 components for every servo system function is now available from Kearfott. This series offers the system designer complete latitude in miniaturization of his second-generation systems, with the performance and reliability heretofore found only in much larger units.

Stainless steel housings, shafts and bearings protect the units against environmental extremes and contribute to stability under shock, vibration, and temperature fluctuations. • Standard 26-v, 400 cps excitation. • Synchro and resolver accuracy ±10 min. • Operating temperature range −55° to +125°C. Computer-designed for optimum performance.

CHARACTERISTICS

SYNCHROS	VOLTAGE (400 cps)	CURRENT (amps)	IMPEDANCE INPUT	IMPEDANCE OUTPUT	T.R.	TOTAL RMS NULL (mv)	ERROR (min)
Transmitter							
CJO 0565 100	26	.045	576/74.7	94.2/71.4	.454	50	10
Control Transformer							
Low Z-CJO 0555 100	11.8	.040	280/70°	1050/72°	1.765	50	10
High Z-CJO 0555 900	11.8	.016	630/74°	2440/74°	1.765	50	10
Differential							
CJO 0595 100	11.8	.040	280/74°	350/69	1.154	50	10
Resolver							
Low Z-CJO 0585 100	26	.0485	537/64.7	677/74	1.0	50	10
High Z-CJO 0589 100	26	.0145	1795/68.1	2210/76	1.0	50	10

Weight: 0.90 oz; Length: 1.250 in.

SERVO MOTORS

	J126-06	J126-02
No-Load Speed	9800 rpm	9800 rpm
Stall Torque	0.12 in. oz	0.12 in. oz
Rotor Moment of Inertia	0.175 gm cm²	0.175 gm cm²
Voltage $\phi 1/\phi 2$ (400 cps)	26/36-CT	26/26
Power Input/Phase	1.7 w	1.7 w
Duty	continuous at stall	

SYNCHRONOUS MOTOR

	CJO 0172 200
Pull-In Torque	0.06 in. oz
Pull-Out Torque	0.10 in. oz
Pull-Out Power	4 w
Length	1.24 in.

MOTOR GENERATORS

MOTOR	CJ40812001	CJO0812650
Voltage $\phi 1/\phi 2$ (400 cps)	26/36-CT	26/36-CT
Power /ϕ	1.5 w	1.5 w
No-Load Speed	8000 rpm	8000 rpm
Stall Torque	.12 in. oz	.12 in. oz
GENERATOR		
Voltage (400 cps)	26 v	26 v
Power	1.5 w	1.5 w
Volts/1000 RPM	0.1 v	0.1 v
Null	13 mv	10 mv

Weight: 1.05 oz; Length: 1.507 in.

GEARHEADS, BRAKES, CLUTCHES

Size 5 gearheads range in reduction ratios from 20:1 to 1019:1 for servomotors and motor tachometers above. In addition, Size 6 clutches, brakes, and brake-clutches are available.

Write for complete data

KEARFOTT DIVISION
Little Falls, New Jersey

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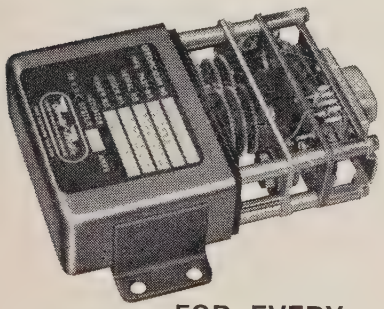
Other Divisions: GPL, Librascope, Link

No. 103 on Reader Service Card

BENDIX-
PACIFIC
SERIES 130
UNIVERSAL
TIMERS



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APPLICATION WHERE
ACTION OCCURS AS A
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★ Constant Speed Motors
±5% ungoverned ±1% governed
★ Modular gear train covers wide timing range. Weight 9 oz.
★ Wide selection of switches, reset clutches, variable inductors and capacitors and potentiometers.
★ Inquire about programming of circuits rated as high as 40 amps.

Contact Bendix-Pacific
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Geneva-Loc • Conventional Rotary
Linear • High-Response •
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TIMERS
Sequential Programming
Repeat Cycle • Adjustable

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THE Bendix CORPORATION

No. 104 on Reader Service Card

AIR CONTROL VALVE has less parts

A 2-position 4-way, poppet type sub-base mounted air control valve is now in production at **Hoffman Valves, Dept. S/A, 2360 W. Dorothy Lane, Dayton 39, Ohio.** The new valve of basic 1-in. capacity is available with ¾-, 1-, or 1¼-in. NPT ports. It is reported that the engineering features incorporated into the valve has reduced the number of parts, increased service life, and simplified maintenance.

The valve uses replaceable resilient seals—a tapered sealing surface assuring tight sealing and long seal life. Moving parts are cushioned by the resilient seals to prevent impact damage. Internal valve parts are interchangeable with other Hoffman 3- and 4-way valve parts.

No. 208 on Reader Service Card

POWER SUPPLY is transistorized

This transistorized power supply will develop a square wave ac voltage from 24 to 30 VDC source to drive inductive loads, as well as loads that vary widely in power factor. It features a circuit design said to effectively eliminate failure associated with inductive loading of square wave ac voltage, says **Arnold Magnetics Corp., Dept. S/A, 6050 W. Jefferson Blvd., Los Angeles 16, Calif.** Designated model 519AC, the unit can withstand a two second overload of up to 80 volt-amps, and will tolerate a line transient of up to 60 volts where adequate heat sink is provided.

Output power is 50 VA with a frequency and voltage regulation of 1.0 per cent for 6-volt line variations. An output voltage of 115 volts, 400 cycles is standard.

No. 209 on Reader Service Card

CRADLE RELAYS have plug-in base

Cradle relays which feature plug-in mounting are now available. Designs include types which have a hermetic seal, open, or flame resistant polycarbonate dust covers, according to **Allied Control Co., Inc., Dept. S/A, 2 East End Ave., New York 21, N.Y.** The mountings mate with commercial 20-pin miniature sockets.

Contact rating is 2 amp resistive and 1 amp inductive at 29 volts dc or 115 volts ac. Units are designed to take 15 g shock under operational conditions and 10 to 55 cps vibration at 0.062 in. double amplitude. Nominal coil power is 1.3 watts; minimum operating power is 50 milliwatts.

No. 210 on Reader Service Card

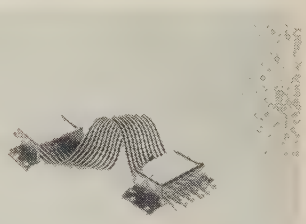
COLUMBIUM BEARING high strength steels

Columbium bearing high strength low alloy steels, No. 6 and No. 7, offering minimum yield points of 50,000 and 45,000 psi, respectively, have been announced by **Armco Steel Corp., Dept. S/A, Middletown, Ohio.** They are available as plates, hot-rolled sheets and hot-rolled strip.

Corrosion resistance is said to be equivalent to mild, non-copper bearing steels. No. 6 exhibits welding properties similar to a 0.20 per cent carbon steel and No. 7 has properties similar to a 0.10 per cent carbon steel.

No. 211 on Reader Service Card

FLEXI-TAPE CONNECTOR has long life



A single cam adjustment provides the electrical continuity, positive gripping, and strain relief of terminating or splicing flexible conductive tape. **Digital Sensors, Inc., Dept. S/A, 6443 N. Figuerosa St., Los Angeles 42, Calif.** says that the connector may be used repeatedly without damage.

Multiple barbed contacts are forced through the conductive metal as well as through the insulation on both sides of the conductive strips. The cam action holds the contacts firmly implanted.

No. 212 on Reader Service Card

NEEDLE VALVE is all-machined

This is an all-machined needle valve that is said to resist corrosion and provide close control of troublesome fluids. The PVC valve is available in ⅛ in., ¼ in., ⅜ in. and ½ in. sizes with either threaded or socket ends, says **Oscar David Co., Inc., Dept. S/A, 285 W. Railway Ave., Paterson 3, N. J.** It is supplied with rubber compound "O" ring bonnet gasket and stem seal.

Line contact seating provides tight closing with little torque. Rated 100 psi at 73.4 deg F, the valve will handle liquids and gases up to 150 deg F with half the room temperature rating, and is said to work equally well at sub-zero temperatures.

No. 213 on Reader Service Card

SENSOR
is hermetically sealed

This dc rate sensor regulates, inverts and feeds a 28 vdc input to an ac gyro motor and pickoff. Output of the microsyn-type pickoff is demodulated, balanced, gain-adjusted and filtered, providing dc output up to 12 volts, according to **R. C. Allen Aircraft Instrument Div., R. C. Allen Business Machines, Inc., Dept. S/A, 333 Commerce Ave., Grand Rapids, Mich.** The sensor has a hermetically sealed gyro and completely potted electrical hardware; its resolution is below 0.05 per cent.

It is insensitive to 100 g shock. Other specifications include: temperature, 0 deg to +185 deg F; constant damping coefficient within ±0.15 per cent of nominal linearity, 1.0 per cent of maximum rate; zero calibration, 0.01 to 0.02 per cent of maximum rate, and a minimum of 500 life hours.

No. 214 on Reader Service Card

DIFFERENTIAL
for servo applications

This miniature differential is designed for loads up to 75 in.-oz. and speeds to 3500 rpm. The model X-1943 is for use in servo systems and for integrating mathematical functions in computing equipment, says **Bowmar Instrument Corp., Dept. S/A, 8000 Bluffton Rd., Fort Wayne, Ind.** Backlash is held to 1½ minutes by a bevel gearing and the unit has a .5 in.-oz checking load.

Various operating configurations are possible owing to hollow shaft construction and, according to the manufacturer, this makes the unit valuable as a breadboarding or a prototype component as well as for production applications.

No. 215 on Reader Service Card

DC AMPLIFIER
occupies little space

This model 98 dc amplifier withstands severe environmental conditions and occupies less than 4 cu in. Low level signals from strain gages, pressure transducers, accelerometers, thermocouples and resistance temperature probes are said to be accurately amplified to a high level dc voltage, says **Video Instruments Co., Inc., Dept. S/A, 3002 Pennsylvania Ave., Santa Monica, Calif.** It contains a solid state low level chopper, a solid state ac amplifier, and a solid state synchronous demodulator.

In telemetry, its output voltage of 0 to ±v dc is suitable for driving a subcarrier oscillator. The bandwidth is 2 kc. Primary power required is 28 VDC.

No. 216 on Reader Service Card

KEARFOTT ACCELERATION SWITCHES

Kearfott's A9548-01 Acceleration Switch is designed primarily as an acceleration sensing switch for low milli-g ranges. It closes a circuit when a given acceleration is applied. Gas damping provides the proper time delay or integration before switch closure. No heaters are required and there is no warm-up time because the gas damping is virtually independent of temperature.

This cylindrical unit is mounted by means of three tapped holes in the base (at one end of the cylinder), and an electrical connector is mounted on the side near the base. Hermetically sealed, the unit meets the shock, vibration, temperature, and other environmental requirements of MIL-E-5272C.

A heavy metal mass, supported by two flat springs, moves to close gold alloy contacts when acceleration is applied. Gas damping is accomplished by means of a graphite piston moving in the sensing mass. Normally mounted level, the acceleration switch responds to gravity and can therefore be used as a tilt switch, since its threshold value is equivalent to a tilt angle of 8½ degrees.

Damping, springs, mass, or material can be varied to meet the user's requirement in the 0.1 to 5 g range, thus making it readily adaptable to other applications.

SPECIFICATIONS

Threshold:	0.150 g±25% (contacts remain open)
Insulation Resistance:	50 megohms min. (500 volts D.C.)
Contact Rating:	0.1 amp non-inductive
Dimensions:	1 9/64" diam. x 2.225" high

Write for complete data

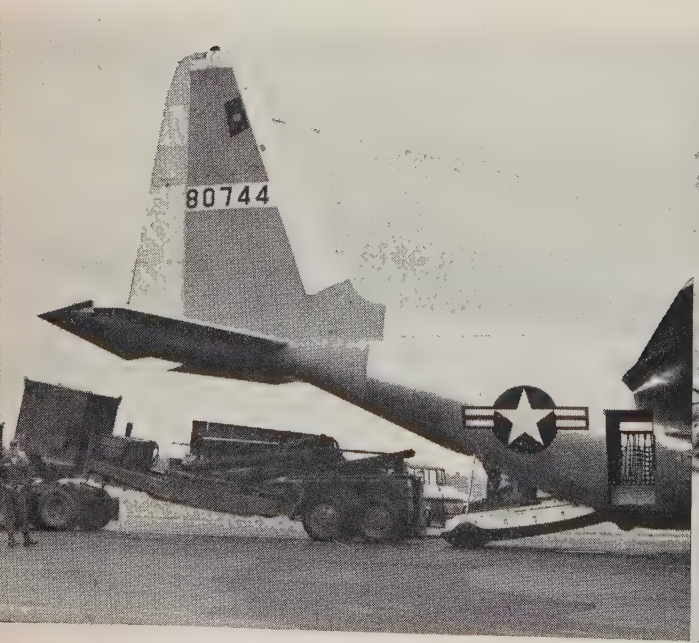
KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

No. 105 on Reader Service Card

Half-mule, half-bird The U.S. Army's Sergeant, now in production, is artillery, and it can traverse terrain where caissons used to go rolling along. And for long, fast hops, the Sergeant can readily be airlifted. The prime contractor, Sperry Utah, wisely selected new, light gages of USS "T-1" Constructional Alloy Steel with 100,000 psi yield strength for the ground support special purpose equipment. USS "T-1" Constructional Alloy Steel is three times stronger than structural carbon steel, thus fabricated components can be made thinner and lighter with no sacrifice in strength. The entire launcher is air-transportable because it weighs only 16,000 pounds—7,000 pounds less than if built with structural

Steel "Keeps America's strength high."



Wide use of USS "T-1" Steel makes the transporter-erector-launcher 7,000 pounds lighter and completely air-transportable.

Frame components of special purpose container transport trailers are "T-1" Steel; launcher boom is also "T-1" Steel, for maximum strength and minimum weight.

All major structural components were designed at an allowable working stress of 66,700 psi.

carbon steel. When your missile support system goes on the drawing board, you can obtain applications and development assistance by consulting the one producer of all basic materials for support hardware and facilities. Whether it's carbon steel or special constructional alloy steels, electrical cable or wire rope...consult

United States Steel

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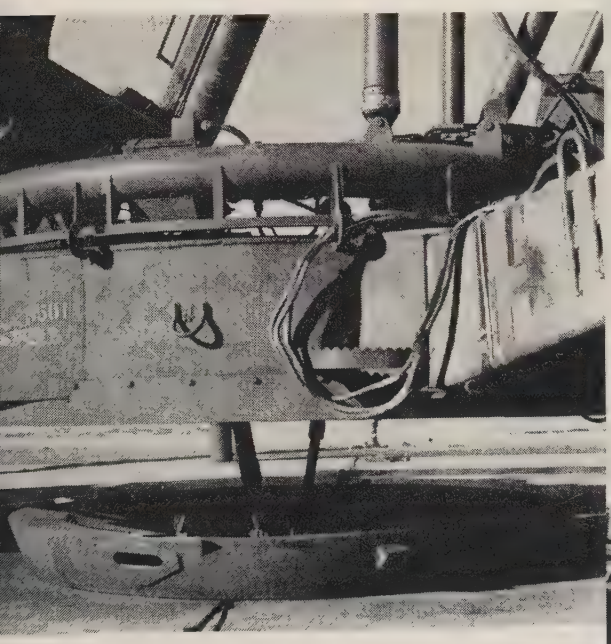


" diameter welded USS "T-1" Steel tubing forms the
us ring of the launching superstructure.

USS "T-1" Steel outrigger legs stabilize the unit in firing position. Also made of "T-1" Steel are the U-frame, extension arms, top and rear tension members and back beam.

New

BULOVA
5 WNS
NARROW BAND
FILTER

Now Bulova Electronics pioneers a symmetrical narrow band type 5 WNS Crystal Filter having a 40 db to 2 db shape factor of 1.25:1. The Bulova 5 WNS is designed with a 2 db bandwidth of less than 0.5% of its center frequency and excellent phase linearity of 90% of the pass band. It features Center Frequency—16.0kc; 2 db Bandwidth—75 cps; 40 db Bandwidth—100 cps; Passband Ripple—±0.5 db; Insertion Loss—6 db max.; Input & Output Impedance—2 k —10%; Overshoot to a pulsed carrier—less than 10%; Operating Temperature—0° to 50°C; Mounting—Octal header or studs.

In addition, the 5 WNS type filter is available at frequencies between 10 kc and 10 mc with .5% to 2% of figure 2 dd of center frequency. For additional information or application assistance, write Department 2106, Bulova Electronics, Woodside 77, N.Y.

BULOVA
ELECTRONICS
DIVISION

No. 106 on Reader Service Card

TINY ACCELEROMETER weighs under 3 oz

This sub-miniature, non-pendulous, constant-damped linear accelerometer weighs less than three oz and is slightly under one cu in. in volume. It provides independent control of natural frequency for any given G-range, says **Minneapolis-Honeywell Regulator Co., Dept. S/A, 40 Life St., Boston 35, Mass.** Control of the natural frequency is achieved through use of variable area fluid coupling.

The LA-800 instrument is said to be ruggedly designed for stabilization or autopilot applications on commercial and military planes, artillery rockets, ballistic missiles and booster rockets on space vehicles. The prototype models have been built and tested. It operates at peak efficiency within a temperature range of —65 deg F to +250 deg F and will withstand shock up to 100 Gs and vibration up to 2000 cps at 30 gs.

No. 217 on Reader Service Card

ACCUMULATOR performs 3 functions

This oil-hydraulic accumulator acts as a power storage chamber, a pressure compensator, and an eliminator of surges and vibration. Connection to a hydraulic circuit is made at a pipe-threaded opening at one end, and hydraulic pressure on this side of the floating piston is made compressible by a charge of nitrogen gas on the other side, according to **Crescent Hydraulic Co., Dept. S/A, 1303 Otsego Road, Allegan, Mich.** The gas is introduced through a valve covered by a protective cap, which bears a safety lock.

The unit is available in six models for 3000 psi service, four for 3500 psi. Overall size is 3 to 5½ in. in diameter, 11 to 39 in. long, and port size ½ to 1¼ in.

No. 218 on Reader Service Card

WIRE CONTACT RELAYS for plug-in installations

These 4-, 6-, and 12-pole wire contact relays are designed for plug-in installation in rack-mounted circuits and assemblies. To facilitate system maintenance, the silver alloy spring contact arms are removable by hand, says **Wheelock Signals, Inc., Dept. S/A, 273 Branchport Ave., Long Branch, N.J.**

The relays are 1½ in. high by 1¾ in deep by ⅝ in., ⅞ in., and 1¾ in. wide for the 4-, 6-, and 12-pole configurations, respectively. They are available with 48 volt dc and 115 volt dc coils to operate in 4½ milliseconds and release in 3 milliseconds.

No. 219 on Reader Service Card

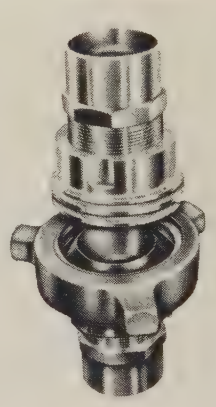
SMALL INVERTER for extreme environments

This solid state inverter is for use under extreme environmental or electrical conditions. Although small, its efficiency range is from 70 to 85 per cent, says **Electronic Div., Globe Industries, Inc., Dept. S/A, 525 Main St., Belleville 9, N.J.** The unit is available in several standard sizes from 15 VA to 200 VA.

The inverter is constructed to exceed the requirements of MIL-I-27273 and MIL-STD-704.

No. 220 on Reader Service Card

CRYOGENIC COUPLING for use with lox



This light-weight, cast-aluminum, cryogenic coupling is for use with liquid oxygen and nitrogen. It provides positive sealing by means of a replaceable semi-soft LOX compatible plastic gasket, mounted in an aluminum seat, according to **Cosmodyne Corp., Dept. S/A, 12833 Simms Ave., Hawthorne, Calif.** The male and female coupling are supplied with dust caps and plugs.

The couplings for oxygen and nitrogen service are identified by green anodize and right-hand threads, and blue anodize and left-hand threads respectively. They are rated at 150 psi operating pressure, 300 psi proof pressure, and 450 psi burst pressure.

No. 221 on Reader Service Card

SWITCH has high sensitivity

This subminiature switch can hold a differential travel of 0.001 in. The operating force is a maximum of 3.5 oz, says **Minneapolis Honeywell Regulator Co., Dept. S/A, Freeport, Ill.** Release force is said to be one ounce maximum.

The switch has a minimum overtravel of 0.003 in. and a 0.008-in. minimum break distance. Electrical rating is 30 volts with 3 amps inductive, 5 amps resistive, and 24 amps maximum inrush.

No. 222 on Reader Service Card

QUICK DISCONNECTS *are non-corrosive*

Designed for uses requiring non-corrosive metal connectors, a new line of stainless steel quick disconnects is now available from **Perfecting Service Co., Dept. S/A, Charlotte, N.C.** The socket, plug, and internal parts are made of 316 corrosion-resistant stainless steel.

The units connect and disconnect lines instantly with a simple push action. No turning or twisting is necessary. A Buna-N seal permits positive sealing and gives long, trouble-free life. An integral shutoff valve in the socket stops flow when the lines are disconnected. The units are rated for working pressures up to 7500 psi when connected. They are available in male and female end connections, ¼ and ⅛ in. sizes.

No. 223 on Reader Service Card

CYCLING TIMER *is sturdy and compact*

These type 553 cycling timers are hermetically sealed and designed to provide accuracy and reliability under severe operating conditions within a range of 5 seconds to 30 hours. An accessory inverter is offered where dc is the only available source, says **Cramer Controls Corp., Electromechanical Div., Dept. S/A, Centerbrook, Conn.** One to five load switches are available, rated 5 amps at 125 or 250 v ac.

Switch actuated cams provide an accuracy of 1 deg at the operating point of any one circuit or 2 deg between the operating points of two circuits. The units, under test, have met operating demands at 70,000 feet, vibration from 10 to 2000 cps at 20 gs, and 50-g 11-ms shock.

No. 224 on Reader Service Card

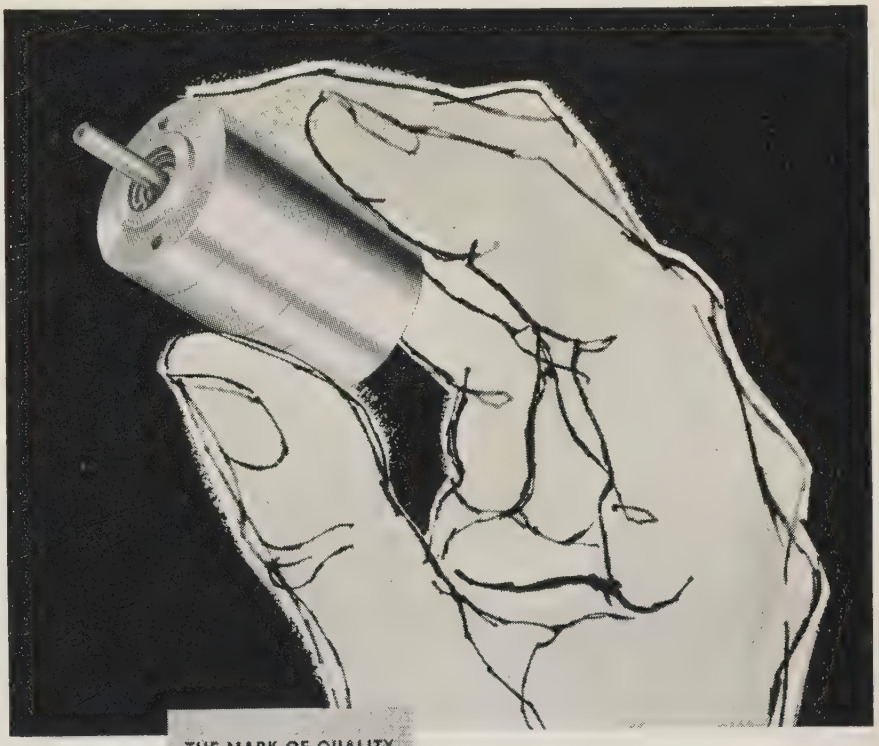
SERVO SYSTEM *used in nuclear reactor*

The position of nuclear rods in a reactor can now be read to a maximum depth of 75 in. by means of a new servo system. Utilizing components manufactured by **Vernitron Corp., Dept. S/A, Carle Place, N.Y.,** the system consists of a synchro transmitter mounted alongside the rod and a synchro receiver at the control center. The system reportedly has an accuracy of ±1 deg in rotation.

The transmitter synchro has radiation-resistant capabilities, through the use of special silicone materials. The receiver synchro also powers an indicator dial used in the configuration. Both 60 cycle synchro units can also be made for use with 400 cycle line frequency for shipboard and for aircraft installations.

No. 225 on Reader Service Card

Type HYLM (1" diameter) Barber-Colman quality permanent magnet motor for precision applications . . . meets military specifications



THE MARK OF QUALITY

BARBER COLMAN

d-c small motors

Type HYLM 1" diameter precision-made Barber-Colman motor is available in three lengths and can be supplied for use on any voltage from 6 to 115 volts d-c. Square brushes, retained by a constant-pressure spring, ensure long brush life. Dynamic braking can be employed if desired. This motor is equipped with R2 ball bearings, has an explosion-proof housing, and meets environmental requirements of MIL-M-8609 (ASG). A quality motor throughout . . . lightweight, compact, efficient. Ask for Bulletin F-10421.

typical applications

PROGRAM SWITCHES

TUNING MECHANISMS

ELECTROMECHANICAL ACTUATORS

COOLING FANS AND BLOWERS

TIMING MECHANISMS

SWITCHING DEVICES

WRITE FOR NEW QUICK REFERENCE FILE

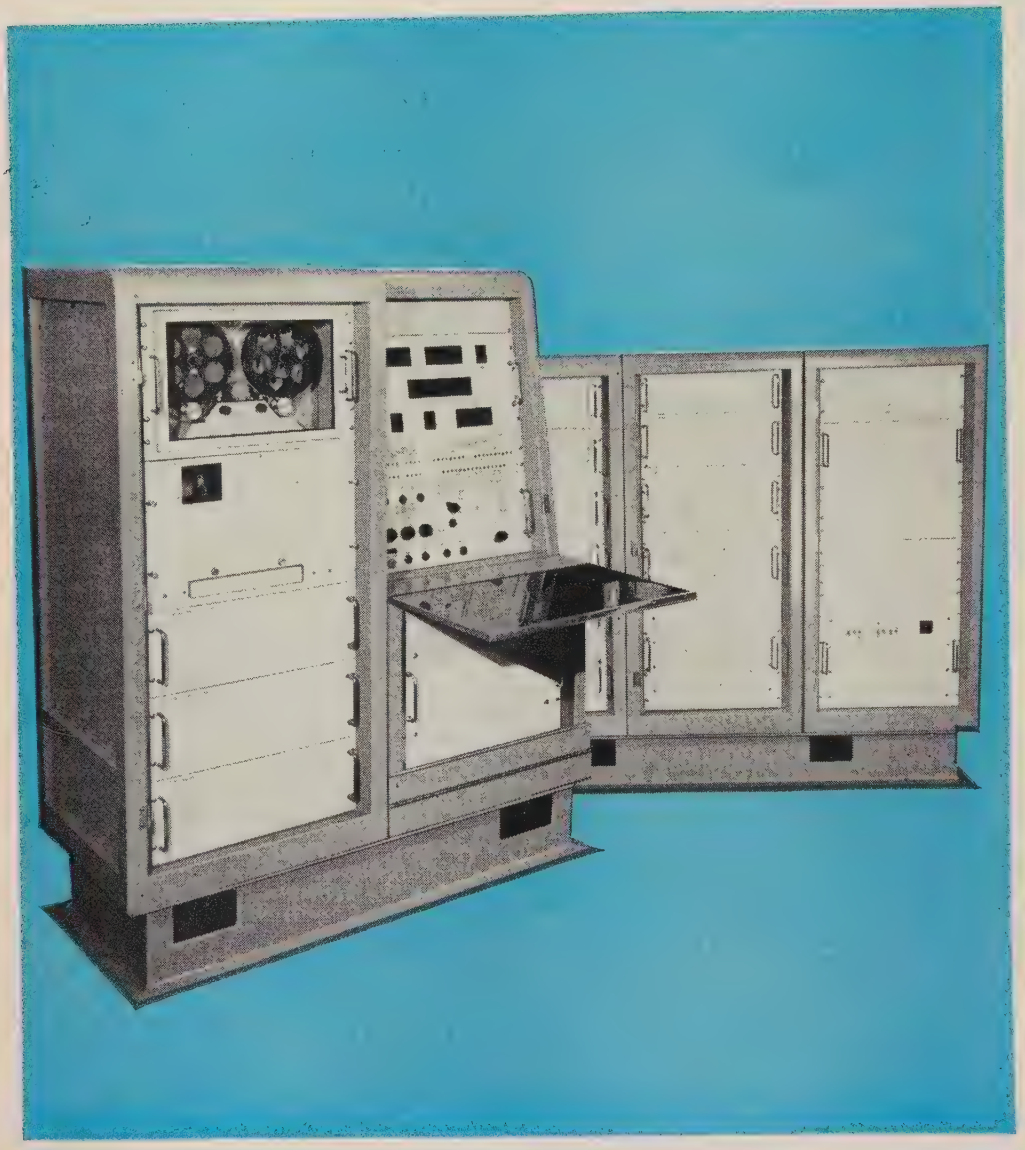
on the complete line of Barber-Colman electrical components, a-c and d-c small motors, tach generators, blowers, gearheads, relays.

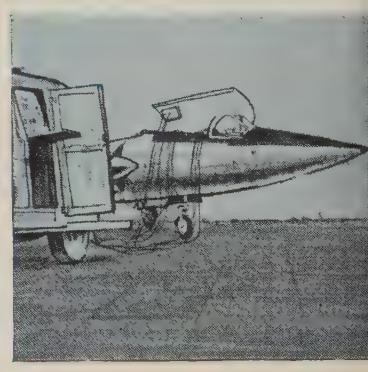
BARBER-COLMAN COMPANY

Dept. S, 1823 Rock St., Rockford, Illinois

No. 107 on Reader Service Card

READY NOW ... BENDIX SYSTEMS





ADAPTABLE TO

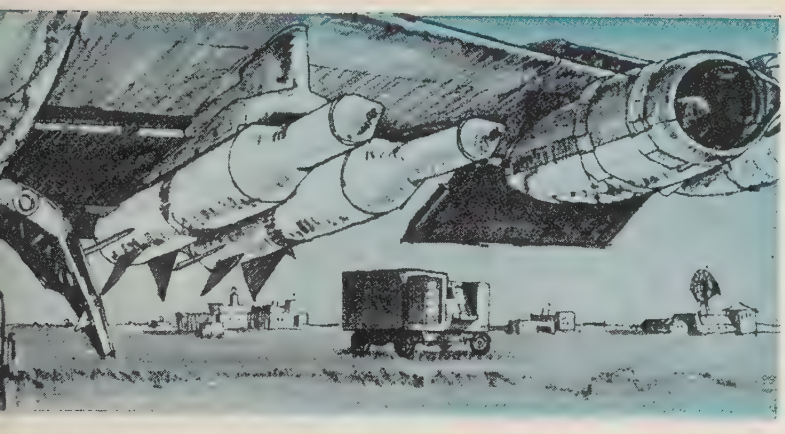
Knowmanship in Action

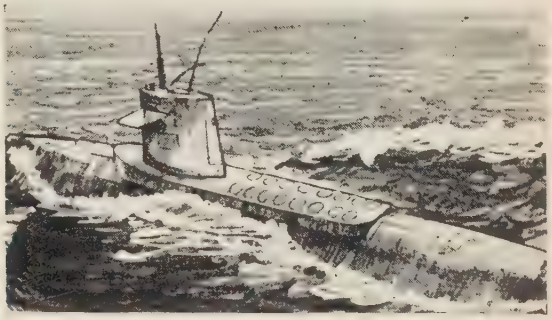
Now in quantity production at Bendix is a Universal Programmer-Comparator designed for automatic Go, No-Go, checkout of all types of air, land, sea, and space systems. Readily adaptable to electronic, hydraulic, mechanical, and pneumatic systems, it is tape controlled and has system logic capability for selecting hundreds of stimuli control channels and thousands of test points as required.

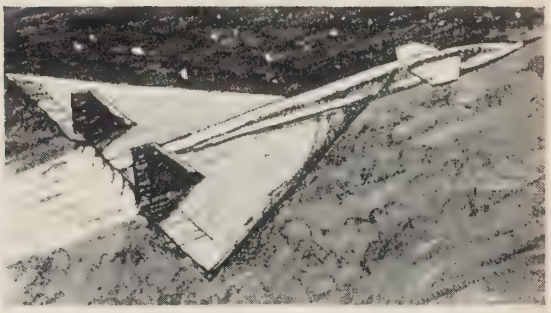
DISTINCTIVE FEATURES OF THE TESTER ARE:

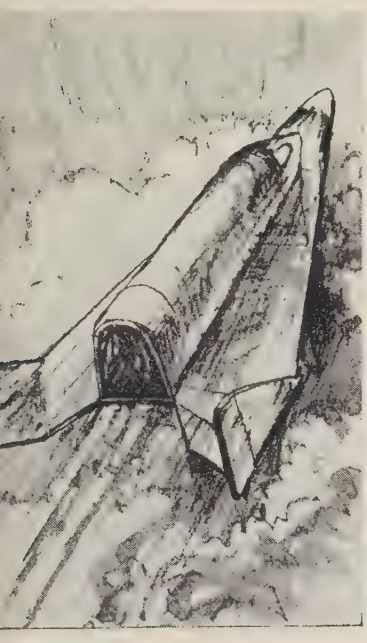
1. Checkout time for complex systems is reduced from hours to minutes. **2.** Minimum skilled technicians can perform complete systems checks with high accuracy. **3.** Visual display and printed record of the test results are provided for the entire testing sequence. **4.** Applicable to in-plant manufacturing as well as to all levels of maintenance activity. **5.** Modular construction permits packaging for either fixed or mobile units.

UNIVERSAL TESTER REDUCES CHECKOUT TIME TO MINUTES









TESTING ALL TYPES OF AIR, LAND, SEA, AND SPACE SYSTEMS

The first application is the USAF's Douglas-built Skybolt Missile. Built to Mil-P-26664A, and designated AN/GJQ-9 by the USAF, the Universal Programmer-Comparator is available as Model PC-300 for commercial applications.

This Universal Tester is the latest Bendix achievement in the Support Equipment field and is another example of the engineering and production skills we have developed over a period of forty years. Whether the need is military or commercial, Bendix can provide the answer that does the job *best.*

TECHNICAL **KNOW**LEDGE + EXPERIENCED **MAN**AGEMENT + SPECIALIZED CRAFTSMAN**SHIP** = **KNOWMANSHIP**

For further information, write . . .

THE Bendix CORPORATION

BENDIX SUPPORT EQUIPMENT

Eclipse-Pioneer Division

TETERBORO, N. J.

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A GOOD MOVE

when you call in FENN

for AERO/SPACE components

- Over 60 years experience in the manufacture of precision components and machinery
- Ultra modern facilities—large diameter machining
- Highly skilled personnel
- Outstanding engineering
- Know-how in machining special aerospace metals and alloys
- Modern metallurgical laboratory
- Heat treating, plating, surface treatment and Dow 17 anodize
- Currently in production—nozzle parts, helicopter main rotors, and gear boxes, parts for gas turbine and jet aircraft engines, components for nuclear reactors
- Resident Air Force Inspection
- Write for Facts About Fenn. The Fenn Manufacturing Co., Newington, Connecticut.

No. 109 on Reader Service Card

CONNECTOR
has fixed contact points

These single pin, compression mounted, Teflon insulated, male-female connectors feature fixed distance contact points. They are adaptable for single or multiple connector use, according to **Jupiter Electronics, Inc., Dept. S/A, 225 E. 144th St., New York 51, N.Y.** The design assures that the connector makes contact continually at one specific point on the male shaft through use of a fixed, spun female contact ring.

The connectors have been subjected to environmental tests of elevated temperatures to 200 deg C coupled with varying humidity and salt spray. When engaged, the connector has an overall length of 1.42 in. When disengaged, the male terminal has an overall length of .920 in. and the female, .835 in. Both are crimped or soldered for wiring purposes.

No. 226 on Reader Service Card

EXPLOSIVE SWITCH
has no moving parts

A recently developed miniature explosive switch, which has a reported reliability of 99.997 per cent, does not use any moving parts. Operation of the switch is simple says **Mimx Corp., Dept. S/A, 1505 Gardena Ave., Glendale, Calif.** The action of an explosive charge establishes a large-area permanent contact, providing virtually failure-proof contact, says Mimx.

The switch withstands unlimited g force, shock, and vibration. It can be used in temperature environments from −100 to +400 deg F. A contact capacity of 20 amps is provided, and the firing current may be adjusted by modifying the explosive element. A delay factor of up to 10 seconds is available for timing purposes.

No. 227 on Reader Service Card

AUTOMATIC BATTERY
for missile use

A silver-zinc primary battery that will activate itself within a maximum of 15 seconds has been developed as an electrical power source for missiles by the **Missile Battery Div., Dept. S/A, Electric Storage Battery Co., P. O. Box 11301, Raleigh, N. C.** The 28-volt model 70 battery will discharge for 12 minutes with an electric load of five amperes.

Voltage is regulated to limit fluctuation to ±5.4 per cent of the 5 amp load. Electrical capacity is one ampere-hour at the one hour rate of discharge. It delivers 6.65 watt-hours per lb or 0.48 watt-hours per cu in. It will provide full power in temperatures ranging from −65 to +160 deg F.

No. 228 on Reader Service Card

REDUCERS, GEARHEADS
are highly efficient

This size 11 frame speed reducer and gearhead, with postless type construction, is lifetime lubricated and is said to offer 95 per cent efficiency. It is available in almost any special ratio, physical characteristic, and mechanical specification, according to **Planet Instrument, Inc., Dept. S/A, 616 S. Lafayette St., Ft. Wayne, Ind.** It has ball bearings throughout and shielded output bearings.

All gears and pinions are hardened and passivated to meet corrosion resistance requirements.

No. 229 on Reader Service Card

SERVO MOTOR
is less than an inch long

This high torque, low inertia servo motor is one-half in. in diameter and 0.968 in. long. It is designed for use in systems where instant response is required, according to **Kearfott Div., General Precision, Inc., Dept. S/A, 1150 McBride Ave., Little Falls, N.J.** Voltage is 26 at phase 1 and 36 at phase 2; power input is 1.7 watts for both phases.

Current, ma, is 75 for phase 1 and 56 for phase 2; frequency is 400 cps.

No. 230 on Reader Service Card

FLEXIBLE SHAFT
for high temperatures

This stainless steel high temperature flexible shaft has a 5/16 in. diameter core that is made of layers of stainless steel wire. The shaft is made to the exacting requirements of the aircraft industry and held to close tolerance, according to **Stow Mfg. Co., Dept. S/A, 87 Shear St., Binghamton, N. Y.** Deflection of the shaft in radians/ft lb can be held to fairly close tolerance.

The unit is said to be excellent for various high temperature applications such as operating the fuel control on jet turbine engines.

No. 231 on Reader Service Card

POSITION FLASHER
is completely solid state

This encapsulated aircraft position light flasher handles an incandescent lamp load from 1 to 5 amps at 28 v dc, weighs 9 lb, and flashes at 85 cpm ±5 cycle. It is operable in any position and is impervious to jet fuel, hydraulic fluid, etc., according to **Aircraft Instruments Co., Dept. S/A, Radnor, Pa.** Size is 2½ inches by 2⅛ inches by 4¼ inches.

Operating temperature range is −55 to +71 deg. C. and vibration range is 5 to 500 cps at 10 G up to +71 deg C.

No. 232 on Reader Service Card

ACCELEROMETER
broadens frequency band

A subminiature accelerometer, which broadens the useful frequency measurement spectrum, has been announced by **Gulton Industries, Dept. S/A, 212 Durham Ave., Metuchen, N.J.**

This model AA-1220 unit has a resonant frequency of 125 kc, providing a useful frequency range to 25 kc. It is reported to be able to measure acceleration levels up to 15,000 g. The optimized sensitivity precludes the possibility of overloading associated electronic equipment and thus eliminates the need for shunt capacitance and added calibration, says Gulton. Additional specifications are: sensitivity—0.3 mv; capacitance—750 uuf; transverse acceleration—7500 g max; transverse response—3 per cent max; temperature range — —65 deg F to +250 deg F.

No. 233 on Reader Service Card

DC POWER SUPPLY
has convection cooling

Development of a line of precision-regulated transistorized DC power supplies with convection cooling has been announced by **General Electric Co., Dept. S/A, Schenectady 5, N.Y.** The convection-cooling feature is reported to provide lower preventive maintenance and quieter operation, with no difference in noise level between on and off.

An exclusive feature of the new line is incorporation of a "constant watts" circuit that protects the units against overloads, short-circuits, misadjustments, and high-line voltages. Elimination of variable auto-transformers and relays has reduced the weight and size of the units, with a resultant decrease in maintenance. The line is available with outputs ranging from 1.5 to 100 volts.

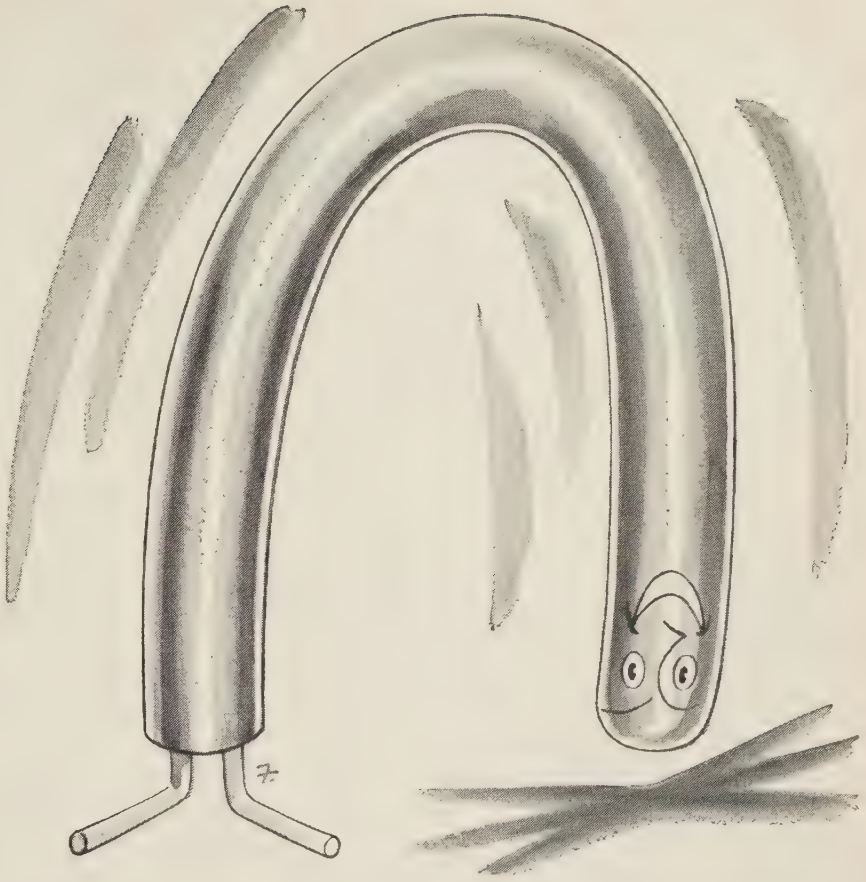
No. 234 on Reader Service Card

MOTOR TACHOMETER
eliminates heater

An advanced motor tachometer design that eliminates external thermostats and internal heaters has been announced by the **Transcoil Div., Daystrom, Inc., Dept. S/A, Worcester, Penna.** The design is said to offer a constant output ratio of ±0.04 per cent and a phase shift of 0.06 deg for each deg C over a temperature range of —55 to +125 deg C.

This line of tachometers is available in conventional frame sizes 11, 15, and 18, with either standard or high torque ratings. By eliminating heaters and thermostats, Daystrom indicates that the design is freed from associated line transients and radio noises.

No. 235 on Reader Service Card



Ceramo®* Thermocouples
will bend over backwards
to fit your job!

All of us "Ceramo*-Couples" can bend to almost any configuration, and we don't break our skins, or lose insulation either! When they put us together, they did the job "right."

Over ten years ago, Thermo Electric invented us. Since then, we've multiplied to so many types and sizes that we can do almost any job — and do it better too! We measure temperatures from minus 450°F to 4000°F and higher. Pressures up to 50,000 psi. don't bother us either. We're rugged! We always give you accurate, fast, sensitive and stable temperature readings.

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TO BOND SANDWICH CORE USE METLBOND 406

today's most advanced metal-fastening adhesive system

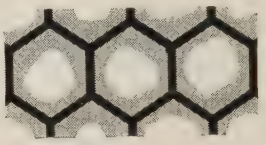
METLBOND 406 is a large-area, one-component, low-pressure, dry, epoxy-based adhesive system. METLBOND 406 will bond similar or dissimilar metals faster, cheaper, better. No core or skin primer is required.

METLBOND 406 IS EASY TO USE. It can be cut, placed in position, and cured with low pressure, at moderate temperatures. Since it is a non-supported system, there is no fabric carrier. Therefore, during cure, it flows...goes where you want it! For most structural metal-joining operations, use METLBOND 406—the "educated" adhesive. It can measurably cut your fabrication costs.

IMPORTANT CHARACTERISTICS OF METLBOND 406

Effective operating temp. range. . .—430F to +200F
Room temp. shear strength. . . . . 5500 psi
Room temp. peel strength (in.-lbs. per 3-in. width). 125
A dual-purpose adhesive system which can be used to bond metal-to-metal, or core-to-skin with equal effectiveness.

FILLETING ACTION OF METLBOND 406



IT FILLETS, CLINGS, AND SEALS OFF EACH CELL WALL

Please write for descriptive product data.

NM

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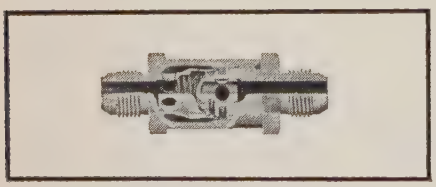
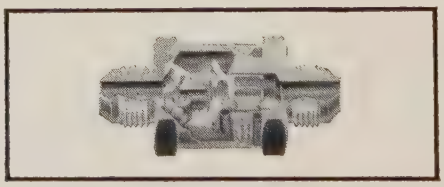
CIRCLE SEAL CHECK VALVES
...no leakage, even with Helium

Proven reliability of the basic Circle Seal design, supplemented by precision production techniques, have made Circle Seal valves renowned for operational dependability in the most critical aircraft, missile and ground support applications.



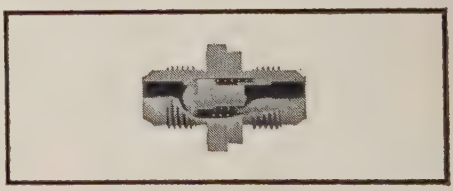
200 SERIES CHECK VALVE

- Absolute zero leakage
- 0-3000 psi.
- Low cracking pressure
- Mounting versatility for any application
- Ideal in applications from vacuum to low or high pressure pneumatic or hydraulic systems encompassing the entire range of exotic fuels and oxidizers



800 SERIES CHECK VALVE LOW PRESSURE

- Perfect sealing from 0-600 psi.
- Low cracking pressure
- Minimum pressure drop
- Unaffected by O-ring swell
- Perfect for applications requiring a combination of low pressure drop and zero leakage



2600 SERIES MINIATURE CHECK VALVE

- Superior performance from 0-3000 psi.
- Leakproof sealing assured by resilient seals
- Minimum size and weight
- Suitable for mounting in any position
- Maintenance-free reliability

CIRCLE ® SEAL
precision valves

JAMES, POND & CLARK, INC.
2181 East Foothill Boulevard • Pasadena, California

No. 112 on Reader Service Card

equipment preview

III—Test and Ground Support Equipment

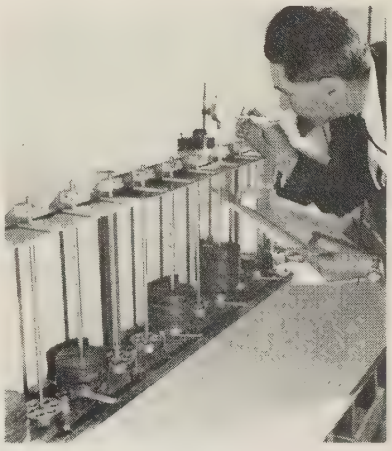
FIFTEEN-UNIT CREEP TESTER SLASHES PROGRAM COST AND TIME

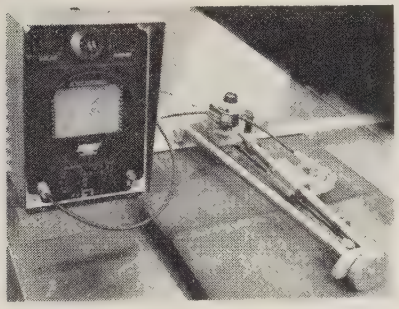
A multi-unit creep test machine designed by Vincent Yuhas, a manufacturing development engineer, reduced the cost of a plastic laminate materials test program by more than 80 per cent, says Boeing Airplane Co., Seattle 24, Wash.

Boeing's test program involved more than 1000 specimens of epoxy resin laminate tooling materials at constant stresses from three to 50 per cent of breaking load. Each test was to be run for 500 hours at room temperature and at 120 deg F.

Yuhas came up with a machine designed to test 15 specimens simultaneously. Weights are placed on free-sliding loading rods to stress the test specimens. The rods are guided by machined slots to apply the full load in the vertical direction. The specimens rest on rollers, so that they can deflect freely.

Deflections are measured by a dial indicator that moves along the top of the load rod rack on a machined steel channel. A sealed water-filled base can be heated to raise the test environment to 200 deg F.



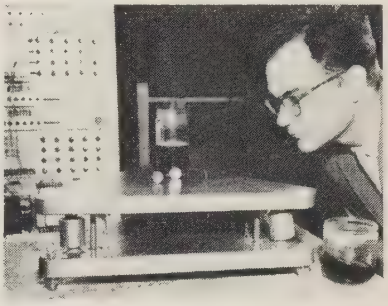


Weld Flaws Are Pinpointed by Ultrasonic Detector

Higher speeds, lower original and operating costs, faster and often more reliable operation, and the absence of radiation danger are claimed as the advantages of its ultrasonic Sonoray* 5 weld inspection unit over X-ray by Branson Instruments, Inc., 40 Brown House Rd., Stamford, Conn. The Sonoray flaw detector sends bursts of sound energy into the welded plate and picks up the returning echo. Homogeneous metal and flawless welds produce a series of pyramidal markers on a CRT that exactly reproduce the path of the sound beam as it bounces from side to side inside the plate and weld. If the sound wave meets any obstacle in its path—a slag inclusion, an unfused area, a hairline crack, etc. —some of its energy is reflected by this discontinuity and generates a vertical pip on the scope. The pip is said to precisely indicate location and extent of the flaw.

Even with hand operation, Branson states, the Sonoray 5 will spot discontinuities as small as 1/16 in. and safely check about a foot of weld per minute. Motorizing the unit and hook-up to recorders or flaw alarms are seen as obvious possibilities, and even completely automatic weld inspection is claimed to be feasible. **73**

* Registered trademark.



Isolation Table Removes Spurious Horizontal Components

Horizontal vibration and motion can be isolated either to or from the top platform of the TBV-1 vibration isolation table, since it is transmitted in neither direction between the table's two platforms. Designed by Tenlo Research, Inc., 9424 Lyndale Ave. S., Minneapolis 20, Minn., the table isolates an instrument on its top platform from as much as ½-in. peak-to-peak hor-

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57 Harper Avenue
TRinity 3-6560

DELCO RADIO
Division of
General Motors
Kokomo, Indiana

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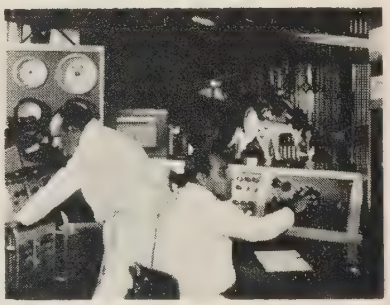
izontal excursion of the bottom platform and the bottom platform from the same excursion of the top platform. Rotational motion about a vertical axis is similarly isolated.

The table can be used to isolate sensitive mechanical and electric instruments and to test and calibrate servo mechanisms, accelerometers, and other sensors by removing spurious horizontal components from vertical accelerations and vibrations. It is intended primarily for applications in which the supported device does not have to be touched during normal isolation operation.

Once precisely leveled, the table will remain level indefinitely. There is no resilient support that could change with age. **71**

Wind Tunnel for Re-Entry Heat Transfer Studies



Stagnation enthalpy and pitot pressure are simulated in a new one-megawatt, arc-heated wind tunnel from Plasmadyne Corp., 3839 S. Main St., Santa Ana, Calif. The tunnel was designed for the study of heat transfer and materials behavior at extreme high-temperature conditions.

The standard heat-transfer simulation range of the tunnel is given as 10,000-30,000 fps of force-flight velocity for a three-inch-diameter, Mach 3 test section. Altitudes can be simulated down to 100,000 ft at 10,000 fps and 20,000 ft at 30,000 fps. At higher altitudes and lower power levels, velocities of up to 35,000 fps have been simulated.

Model stagnation density and enthalpy are matched to the values of the full-scale model in free flight. The test specimens reach an equilibrium state and can be observed visually under re-entry conditions. In glide re-entry tests, runs of up to one hour have been made. **72**

equipment in brief

RESISTANCE THERMOMETER is potted

This model S29 resistance thermometer is reported to produce a positive change of resistance of more than 3 ohms for each degree of temperature change. According to **Minco Products, Inc., Dept. S/A, 740 Washington Ave., No., Minneapolis 1, Minn.**, the potted construction in a filled epoxy case permits immersion in most gases and liquids.

Model S29 has a resistance of 676 ohms, ±½ percent at 25 deg C. Operating temperature range is −55 to +100 deg C. These thermometers are 1⅛-in. long by 5/16-in. in diameter. They may be mounted in a standard fuse clip or with a 5/16 in. cable clamp. They may also be suspended by their leads, which will withstand a pull of at least 5 lb.

No. 178 on Reader Service Card

TRANSDUCER has AC-DC input circuit

A DC output variable reluctance, differential pressure transducer having an AC-DC input circuit is now in production. This model CP53D can measure low pressure differentials with line pressures up to 5000 psi. Pressure ranges of the new unit are from ±0.1 to ±2500 psid.

The single package combines a variable reluctance pressure transducer and a transistorized carrier-demodulator. According to **Pace Engineering Co., Dept. S/A, 13035 Saticoy St., North Hollywood, Calif.**, this combination simplifies dc output operation, while realizing all of the performance advantages of magnetic reluctance transducers, such as frequency response, shock and overload resistance, and long life.

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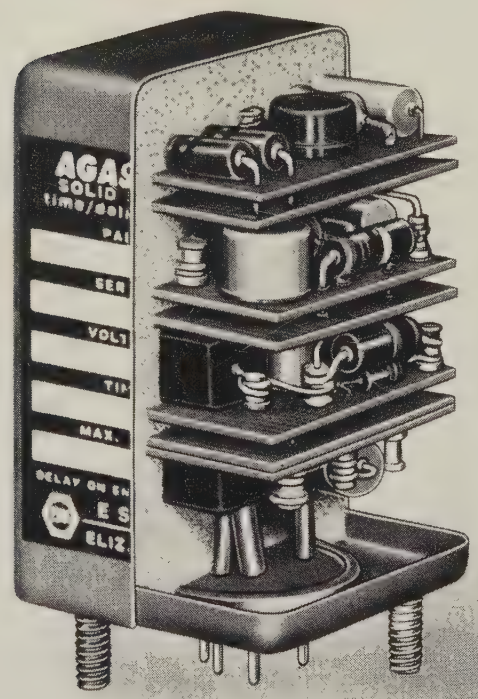
DELCO RADIO

NEW! Solid State time/delay/relays



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No. 114 on Reader Service Card

AUTOMATIC TESTER for system checkout

Automatic dynamic testing of component subassembly or complete system checkout can be accomplished with the Adept 400 model automatic tester developed by **Ortronix, Inc., Dept. S/A, P.O. Drawer 8217, Orlando, Fla.**

Complete flexibility of testing is reported obtainable by control of 295 signal, power, and test control lines with punch tape programming. Ortronix claims that the tester provides greater capability at less cost than any automatic go-no-go check-out system presently available.

No. 236 on Reader Service Card

TEST CHAMBER has dual use

A new line of multipurpose, self-contained environmental test chambers, which can be adapted to 'drf box" welding, is now available. Designed by **High Vacuum Equipment Corp., Dept. S/A, 2 Churchill Rd., Hingham, Mass.**, the chambers can be used with an orbiting electron beam gun to do closed loop welding or to butt-weld long tube sections.

In the environmental test use, it is reported that a simulated rate of climb of 20,000 fpm is attained, using a 16-in. pumping system. The polished stainless steel construction assures low internal leakage rate and reduces maintenance costs. All interior welds are ground and polished. The pumping section is equipped with a sequence valve control which uses a single selector switch for pumping cycle control. Automatic time delays prevent improper cycling.

No. 237 on Reader Service Card

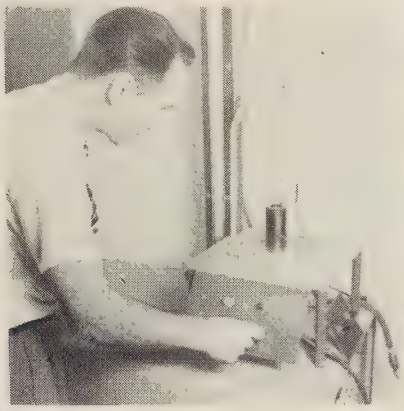
HIGH SPEED TESTER detects tape defects

A magnetic tape tester that detects tape defects as small as one bit at speeds up to 150 ips and packing densities as high as 1500 bits per inch has just been announced. Manufactured by **Potter Instrument Co., Inc., Dept. S/A, Sunnyside Blvd., Plainview, N.Y.**, this model 3320 unit include a high speed, high performance digital magnetic tape transport, manual pushbutton control unit, dual record-playback head, record-playback amplifiers, and logic chasis with fault detector plug-in cards and space for up to 16 channels.

Two combinations of tape speed and packing density can be selected manually, and for each combination, one of two threshold levels can be chosen. Threshold levels are continuously and individually adjustable for each playback amplifier, says the company.

No. 238 on Reader Service Card

MICROMETEORITE DETECTOR uses variety of inputs



Four different techniques for measuring micrometeorite impacts have been announced by **Acton Laboratories, Inc., Dept. S/A, 533 Main St., Acton, Mass.** Techniques include use of a sensitive crystal microphone directly in contact with exposed surface, a grid wire, thin film, and a photoflash detector.

Particles about 2 micron in diameter can be measured with the microphone system: weight is 1 lb, volume 27 cubic in., power required 140 milliwatts. The grid wire system weighs ½ lb, has a volume of 24 cu. in., and negligible power requirements. The thin film system weighs 3 lb, has a volume of 48 cu in., and requires 200 milliwatts/hr of power. The photoflash system weighs about 1 lb, has a 120 cu in. volume, and requires 140 milliwatts of power.

No. 239 on Reader Service Card

CRYOGENIC RECHARGER is truck-mounted

The Model 2100 L transportable recharger, a lightweight, high-capacity, truck-mounted Dewar tank and pumping unit, provides low and medium pressure liquid delivery, and high pressure liquid or gas delivery of oxygen, nitrogen or argon for industrial cryogenic service, according to **Standard Steel Corp., Dept. S/A, 5001 S. Boyle Ave., Los Angeles, Calif.** Featured are high-strength aluminum vacuum-jacketed tank construction and a high-strength reinforced plastic operating and control compartment.

Maximum reliability can be provided through use of a fluid heater and, as a standby, the truck engine for the vaporizing system heat sources. Liquid capacity of the tank is 230,000 scf oxygen gas, plus five per cent vapor space. The unit is available with a 35-gpm, 300-psig transfer pump and a pumping system that delivers 25,000 scfm at 3000 psig. The inner vessel operates at 25 psig.

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develops these outstanding coated asbestos cloths

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R/M No. 607 for chemical and abrasion resistance to 500°F
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Raybestos-Manhattan

An excellent example of R/M's capability in the aircraft and missile field is its development of these outstanding coated cloths.

R/M No. 604 is a wire-inserted, woven asbestos fabric coated with Neoprene. It is ideal for use where high temperature (2000°F) flame penetration resistance is required. And its light weight is a plus value when it is used as a firewall material in aircraft. R/M No. 604 meets FAA specification CAR-04B-486 "Fire-Resistant."

R/M No. 606 is a silicone coated asbestos cloth which retains its flexibility even after extended exposure to 500°F and intermittent exposure to temperatures as high as 650°F and as low as −100°F. It also has excellent resistance to ozone, sunlight and oil.

R/M No. 607 is a Teflon*-impregnated asbestos cloth which combines the complete chemical resistance and engineered properties of Teflon with desirable qualities of asbestos cloth to provide great flexibility, compressibility and abrasion resistance.

R/M's experience in the manufacture of packings, gasket materials, and specialty products to meet the exacting and varied requirements of the aerospace industry is at your disposal — call on R/M whatever your needs.

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PACKINGS

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MECHANICAL PACKINGS AND GASKET MATERIALS

COOLING UNIT for GSE use

Airborne cooling units, modified for use in ground service equipment, are now being marketed by the **Lear-Romec Div., Lear, Inc., Dept. S/A, 3171 So. Bundy Drive, Santa Monica, Calif.**

One unit in the line was developed for cooling the klystron amplifiers for the Eagle missile guidance system. This unit has a nominal heat dissipation rate of 9375 watts. It is reported that Lear is developing other airborne liquid-to-air heat tranfer systems, for GSE use, having cooling capacities between 100 and 10,000 watts, with operating temperatures in the −65 to 250 deg range.

No. 241 on Reader Service Card

BOMB SYSTEM for reentry vehicles

This SOFAR sound generator for underwater detonation is used to fix the reentry locations of missile and orbital test vehicles or bodies in order to expedite recovery from the water. It has a completely out-of-line, 90 deg rotational fuze rotor for failure-proof self-arming and safeing, according to the **Mimx Corp., Dept. S/A, 1505 Gardena Av., Glendale, Calif.** Absence of shear sliding mechanisms makes the fuze mechanism impervious to side g forces, the maker says.

It will withstand temperatures of 350 deg F continuous, 500 deg F for 20 minutes. When a predetermined arming depth is reached, the fuze train is placed in perfect alignment, ready for firing. At a subsequent and greater predetermined depth, the firing pin piston is actuated by hydrostatic pressure.

No. 242 on Reader Service Card

RADAR TEST SETS have many uses

Two multipurpose radar test sets are now available for operation in a frequency range of 2700 to 10,500 mc. Each set is a combination of power meter, frequency meter, spectrum analyzer, signal generator, and synchroscope. Both models are manufactured by **Polarad Electronics Corp., Dept. S/A, 43-20 34th St., Long Island City, N.Y.** The Model CTS-24 covers the 2700-3550 mc range; the Model CTS-810, the 8500-10500 mc range.

These new models feature display and power spectrum of modulated and unmodulated RF signals, field levels (5 dbm to 30 dbm), direct reading precision frequency meter, FM and CW outputs, synchroscope sweep lengths of 5, 20, 50, 250, and 4000 microseconds, and single or multipurpose group identification and decoding.

No. 243 on Reader Service Card

No. 116 on Reader Service Card

CORONA PICK-UP NETWORK now available

A corona pick-up network is now available for corona test set users who have adequate scope facilities and a corona-free testing transformer. According to **Peschel Electronics, Inc., Dept. S/A, RFD No. 1, Patterson, N.Y.**, the unit consists of a corona-free high voltage capacitor and a suitable RF choke with input and output connections. It is an L-C voltage divider designed to resonate at approximately the correct frequency and to match the pulse amplifier/scope detector combination used in corona test sets.

Use of large corona shield on top and single-ended mounting of corona-free capacitor is said to be the ideal geometry for corona-free operation. Corona pulse from this L-C divider are available at a BNC coaxial connector. Input is the top corona shield and the grounded high voltage return post.

No. 244 on Reader Service Card

PRESSURE TRANSDUCERS for flight data

Absolute and differential pressure transducers are available for operation at —55 to +120 deg C, says **Bourns, Inc., Dept. S/A, 6135 Magnolia Ave., Riverside, Calif.** A high temperature differential unit is also available that can go up to +232 deg C.

Both transducers meet the following specifications: range—0-2 or 0-100 psi; resistance—1 K to 10 K ohms; resolution—0.2 to 0.5 per cent; linearity—0.6 per cent; hysteresis—0.5 per cent; power rating—0.8 watt at 45 deg C. Outputs are linear with pressure, altitude, or air speed.

No. 245 on Reader Service Card

MAGNETOMETER is light and compact

This magnetometer is 7 in. long and 3 in. in diameter. It is said to be capable of measuring the minute magnetic anomalies encountered in space, underwater, and subterranean studies, according to **Arnoux Corp., Dept. S/A, 11924 W. Washington Blvd., Los Angeles 66, Calif.** It is suitable for detecting magnetic anomalies of 0.1 gamma or less and relays data in digital or analog form.

In the digital mode, data are presented as an alternating current potential varying in frequency with the polarity and magnitude of an ambient magnetic field. Analog data are presented as an ac signal varying in phase as the ambient magnetic field varies.

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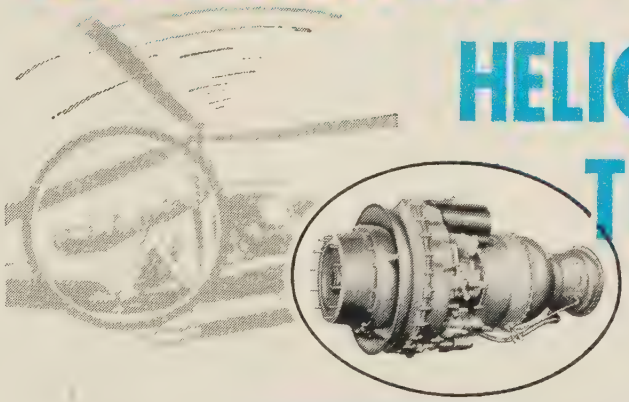
The CONTINENTAL T72-T-2 HELICOPTER TURBINE



▶ **PERFORMANCE**. . . 500 SHP with high economy (0.67 SFC) . . . multifuel capability (all JP, Diesel, kerosene, gasoline).

▶ **RELIABILITY**. . . due to ruggedness and simplicity of design. Sturdy 2-stage compressor . . . all-steel rotating system, foreign object-tolerant . . . anti-icing inlet . . . fail-safe dual-element fuel pump . . . trouble-free fuel distribution . . . emergency fuel circuit with manual controls.

▶ **INSTALLATION ADVANTAGES**. . . Extreme compactness (19-inch maximum diameter; 42-inch overall length) . . . straight-out rear exhaust without obstructions or turns . . . front power output on engine center line . . . front reduction gear surrounded by cool air . . . high accessibility (all accessories mounted around waist) . . . Optional mounting—single-plane, two-plane, or cantilever . . . 210 pounds total weight.

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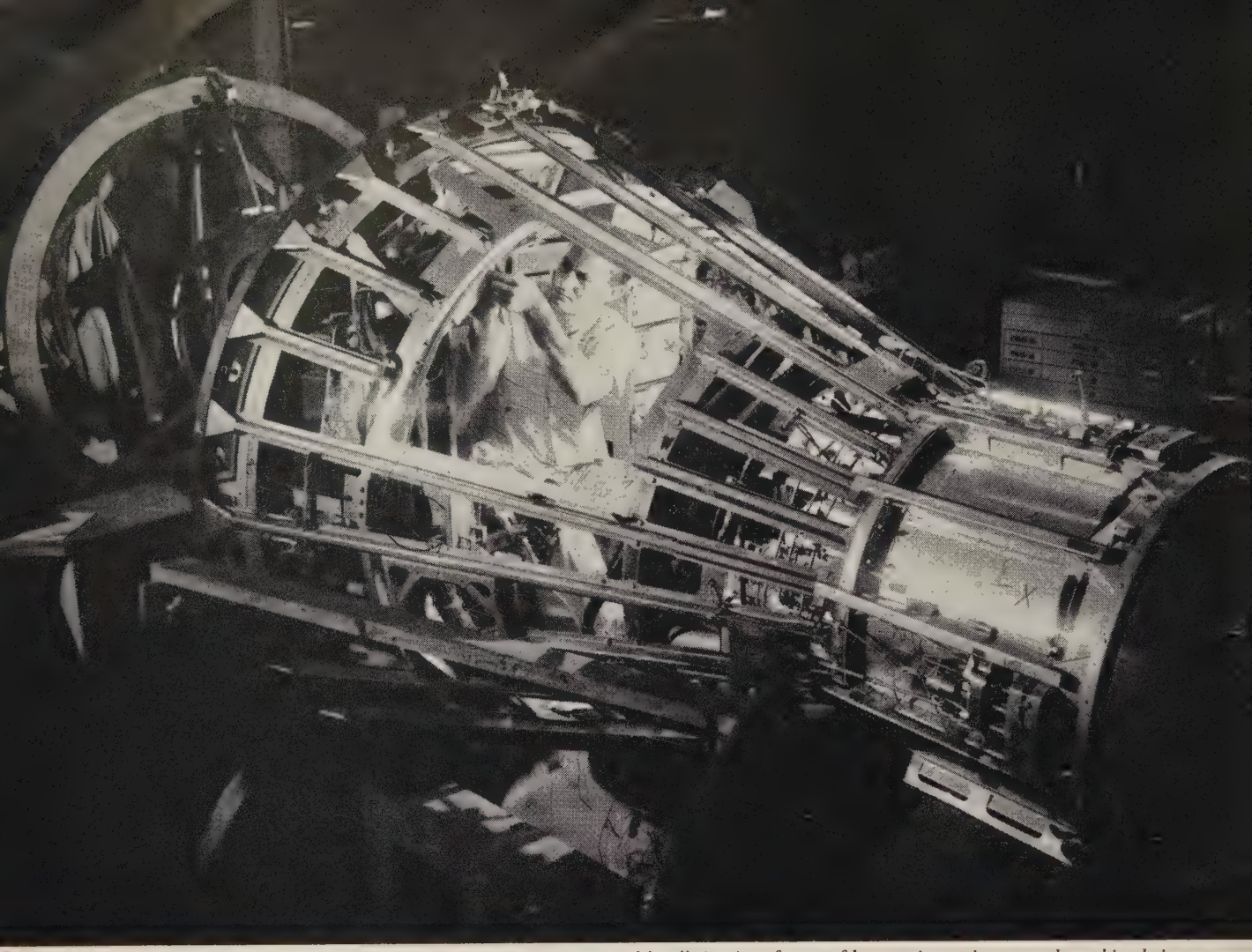

Mercury capsule's all-titanium frame of hat-section stringers and machined rings.

45,000 inches of welding

Titanium construction clinches record of reliability with Mercury capsule!

Mercury's astronaut, and all that was at stake with him, rode out the big shot safely in a titanium structure. Chosen for its light weight, its strength and rigidity at high temperatures, its ease of fabrication, titanium has passed another milestone in its growing history of reliability.

Project Mercury's pressurized capsule, its antenna and parachute housings and the adapter section mating it to the booster are basically titanium structures. They consist of a titanium inner skin attached to a framework of titanium stringers and rings. Beryllium and Rene 41 heat shielding "shingles" are fastened to the outside of the capsule.

The use of titanium has saved "considerable" weight over other metals of similar strength and endurance in the all-critical weight battle in the Mercury capsule and adapter section where ounces were fought for.

This report has been prepared by Titanium Metals Corporation of America in the belief that performance of titanium in the space capsule may provide information of use to you in design and construction of weight-critical airframe structures, whether they be in VTOL or STOL aircraft, or vehicles to operate in space.

Rigidity and strength at high temperatures . . . and 20 G's! Shaving off pounds was not enough for Mercury's designers. One of the big factors in the selection of titanium, which is as strong as most steels, yet weighs 44% less, is its ability to retain its strength and rigidity at high temperatures.

During the launch phase, the all-titanium adapter section reaches 600F. The titanium stringers in the capsule reach 600F during re-entry; the inner skin reaches 200F. Here titanium construction proves its high performance and reliability. Mercury capsule is designed to withstand 20 G's.

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Titanium construction inherently rigid. Titanium lends itself to an actually stiffer construction even though its modulus is somewhat lower than steel's. The answer is a greater cross-section made possible by the less dense titanium. Moreover the metal will retain its stiffness over a wide range of temperatures.

Added stiffness and efficiency can be gained by "rigidizing" or beading. Mercury inner skin, which is also the cabin inner wall, consists of two layers of 0.010" commercially pure titanium, welded together to form a single "sandwich" structure. The inner layer is flat-rolled. The outer layer has been stiffened with corrugations approximately 3 inches in length and ½-inch wide. The result is a 0.020" titanium section that is equal in rigidity to an 0.050" section . . . 150% increase in efficiency.

45,000 inches of reliable welds per capsule. Project Mercury capsule, in addition to its high G loadings and temperature requirements, is pressurized to maintain its cargo of human life. Welds *must* be reliable.

According to McDonnell Aircraft, St. Louis, Mo., developers and manufacturers of the capsule, there are 24,500 inches of seam and butt weld and 20,500 inches of spot weld in each capsule . . . 45,000 inches of welding. The performance has been repeated in 20 production capsules.

Here indeed is a better focus on the reality of titanium welding!

All fusion and seam and spot welding was done "open air." Fusion welds were inert-gas shielded, tungsten-arc, using trailing and backup shields. Welds are as strong or stronger than parent metal, McDonnell reports.

Spot and seam welding was accomplished on standard production equipment, with techniques similar to those used on the stainless steels.

TMCA: your information source. If your missile or aircraft problems revolve around requirements for a rigid, high strength structure at temperatures from *minus* 433 to plus 1000F . . . with high corrosion resistance, including immunity to atmospheric attack, titanium may easily be your best answer. The reliability on which the makers of the Mercury capsule placed their faith can work for you.

We suggest you get in touch with the nearest Titanium Metals Corporation of America sales office or write directly to our Technical Service Department for information on titanium application . . . fabrication . . . competent fabricators. Why not write today . . .

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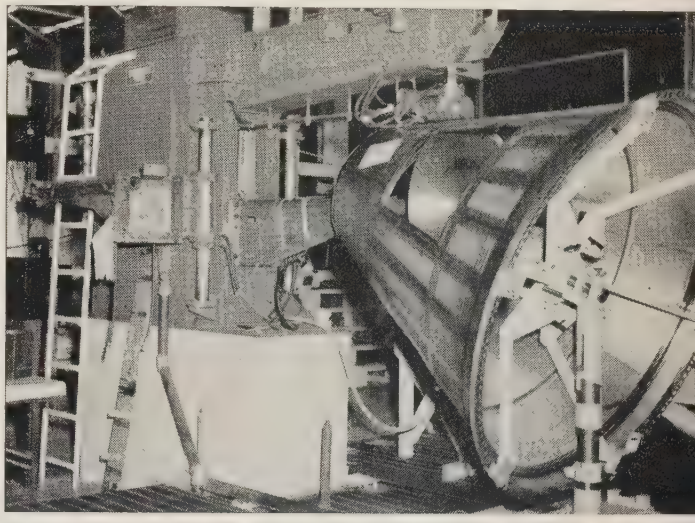
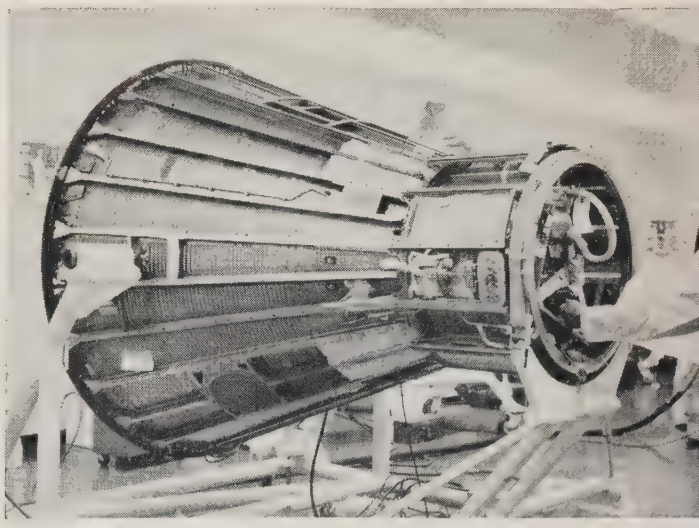
Titanium inner skin consists of two truncated cones 6½' high by 6½' at base, welded together. Cones are formed from trapezoidal sections, butt-welded together. One cone consists of 0.010" beaded titanium, for added stiffness; the other cone of flat-rolled 0.010" titanium. After butt-welding, each cone is individually pressure tested.



Cones are joined by seam-welding, the beaded cone on the outside, following spot-welding for position. Approximately 24,500" of seam weld are used in each capsule. A circumferential pass is made between each corrugation and a vertical pass adjacent to the corrugations. Joined cones are also proof-tested.



Basic titanium capsule structure consists of welded, two-layered cones which are spot welded to the titanium frame. The housing and adapter sections are not pressurized and consequently the skins are riveted to the frame in these areas.

PRESSURE TRANSDUCER 0.035 inches thick

This pressure transducer, which is one inch square, has a sensitive area of one square centimeter, and responds only to normal forces. It has a high frequency response and sensitivity, good linearity, and low hysteresis, according to **Spitz Laboratories, Inc., Dept. S/A, Yorklyn, Del.** It may be used over a range of pressures from 15 in. mercury vacuum to 100 psi.

The transducer is applied directly to plane or curved surfaces. It changes capacity with pressure and may be used with bridge and resonant circuits. Thin sheets of embossed high strength alloy are used for the elastic elements. The dielectric is mica, and the covers are saran film.

No. 247 on Reader Service Card

SIGHTING TELESCOPE for flight tracking

This model WS-10 sighting telescope is used for tracking objects in flight, boresighting, and industrial aligning and measuring. It is of the monocular refracting type and uses interchangeable eyepieces of 10-power or 20-power which mount at a 45 deg angle to the main objective axis, according to **Wollensak Optical Co. Dept. S/A, Rochester, N. Y.** Hinged port covers at each side of headrest open to expose diopter scale of the scope eyepiece for focusing.

Replaceable reticle is provided with variable intensity illuminations for night operation. The telescope is usable under extreme climatic conditions and can withstand the effect of vibrations created by power driven tracking mounts.

No. 248 on Reader Service Card

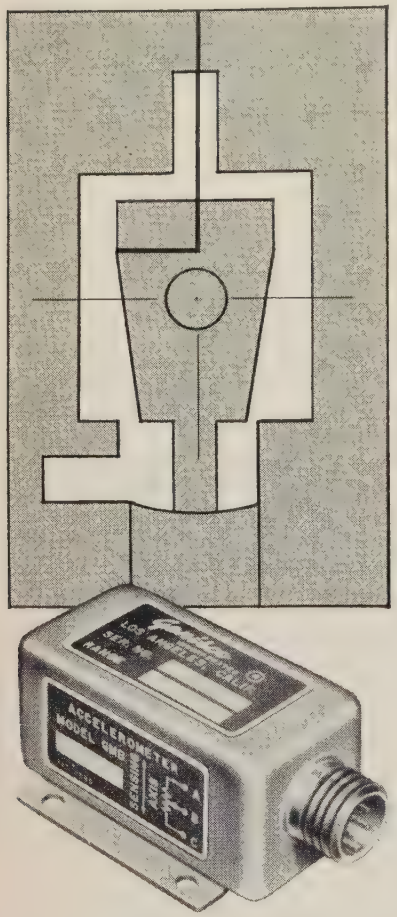
HIGH VACUUM OVEN for research uses

This high vacuum oven is a complete bake-out system. The console cabinet encloses the oven, pumping equipment and vacuum gauging, according to **Gruenberg Electric Co., Inc., Dept. S/A, 9 Commercial Ave., Garden City, N. Y.** A backfill gauge and valve is included for inert gases.

Two models, HVO and VVO, are available. Two pumping systems are also available for operation to 10 microns or 10.5 mm of mercury. Oven temperature is controlled to 500 deg F by an indicating thermostat. Three sizes, either front or pit loaded, are obtainable.

No. 249 on Reader Service Card

SELECTIVE
Gas-Damped
SENSITIVITY

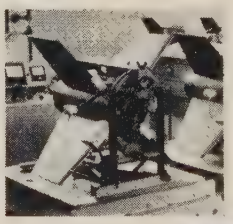


GENISCO
GMB SERIES
ACCELEROMETERS
for airborne applications

- CONSTANT DAMPING
- POTENTIOMETER PICKOFF OR SWITCH CONTACTS

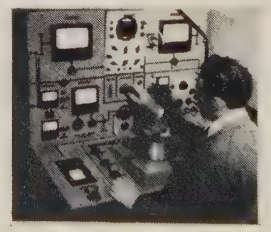
Genisco's GMB Series Accelerometers feature the advantages of gas damping which remains constant over wide temperature ranges for extreme accuracy and consistency. These units are ruggedly designed and constructed to operate reliably under conditions of high vibration and shock. The GMB Series Accelerometers are hermetically sealed units, available with either precision potentiometer pickoff or switch contacts . . . Standard or custom models.

Genisco INCORPORATED
2233 Federal Ave., Los Angeles 64, California
No. 164 on Reader Service Card

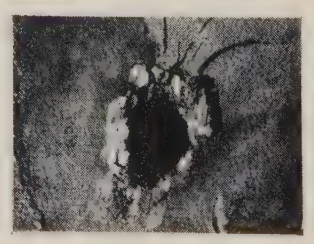


Very High Production Standards

Rigorous Quality Control



Firing Accuracy



SS.10 SS.11
Anti tank missiles designed and manufactured by
NORD-AVIATION 2 à 18, RUE BERANGER CHATILLON s/s BAGNEUX SEINE - TEL. ALESIA 57-40

No. 165 on Reader Service Card

MAGNETOMETER
is portable, efficient

This portable magnetometer for detecting and measuring magnetic field changes ranging from 5 to 5000 gammas is said to be highly sensitive. Power consumption is one-tenth of a watt, according to **Minneapolis-Honeywell Regulator Co., Dept. S/A, 40 Life St., Boston, Mass.** It is designed for industrial and laboratory uses to maintain a constant magnetic field or detect minute changes in the field.

The instrument can be used in degaussing ships at sea, geodetic and geological surveys, prospecting for oil and minerals, or in such military operations as locating land mines or exploding mines on approach of a ship or tank. It uses a single fluxgate magnetic sensor. A field cancellation control cancels out the known magnetic field so that the instrument measures only actual changes.

No. 250 on Reader Service Card

OIL DISCONNECT
for ground servicing

This dripless coupling is designed for use with MIL-L-7808 synthetic oil and MIL-C-8188 corrosion-preventive oil over a temperature range of —65 to +250 deg F. It is rated for an operating pressure of 500 psi, says **The Weatherhead Co., Dept. S/A, 300 East 131 St., Cleveland 8, Ohio.**

The nozzle is completely leakproof and dripproof, says the company, during coupling or uncoupling. Couplings are available in aluminum, brass or stainless steel.

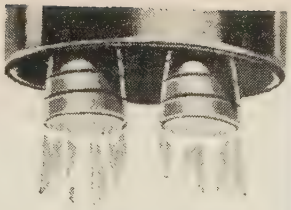
No. 251 on Reader Service Card

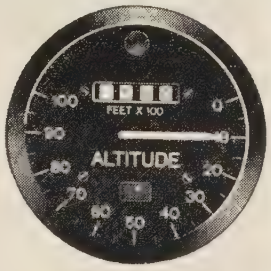
TAPE RECORDER
can survive 1500 g

A hermetically sealed, miniature, magnetic tape recorder has been designed to record through a 500-g impact deceleration and to survive a 1500-g shock. According to **Erstrex Corp., Dept. S/A, 6601 Romaine St., Hollywood 38, Calif.**, the unit is designed to record more than 30 seconds of analog data during flight of a surface-to-surface missile.

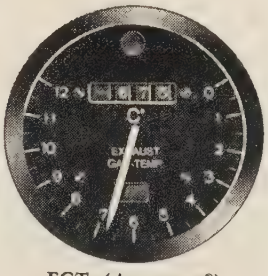
The data are recorded on 14 tracks of 1-in. tape. Recording can be made by an in-line 14-track head or a staggered array of two 7-track heads. Cross-talk is reported approximately 40 db below signal for the staggered arrangement and 34 db for the in line 14-track head. In both cases, gap scatter is a maximum of ±50 microinches. Westrex indicates that the unit will function accurately under sustained vibrations to 20 g acceleration to 8 g along the Z and Y axes, and 25 g along the X axis.

No. 252 on Reader Service Card

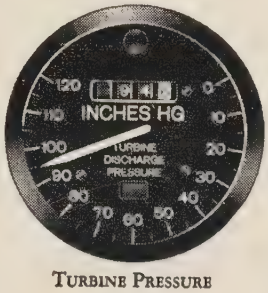




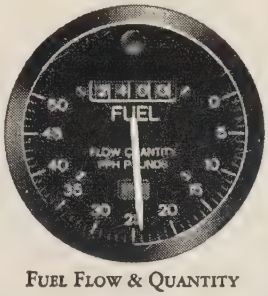
ALTITUDE



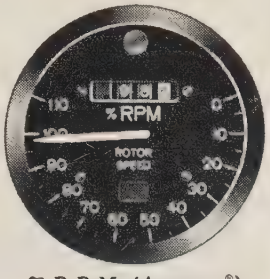
EGT (AUTOTEMP®)



TURBINE PRESSURE



FUEL FLOW & QUANTITY



% R.P.M. (AUTOTAK®)

HOWELL
INSTRUMENTS

COMPREHENSIVE INSTRUMENTATION

HOWELL INSTRUMENTS are calibrated for use with all transducers for the measurement of the phenomena encountered in all phases of aircraft and missile development, test and operation. Each instrument is completely self-contained (miniaturized, silicon transistorized, servo-driven, hermetically sealed) with Zener reference, power supply, amplifier, servo motor, cold junction compensation as needed and the 144-inch slide-wire and punched tape to linearize e.m.f. for exact, counter-type digital readout. Needle pointers are provided for quick reference. Accuracies are within 0.1%. Available in 3"-dia. MS33639 and 2"-dia. MS33598.

Styled Series BH183 & 185—*The Instrument with the Tape-Slidewire*—these instruments are produced by the makers of the JETCAL® Analyzer, the only jet engine tester used throughout the world!

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Sales-Engineering Offices:
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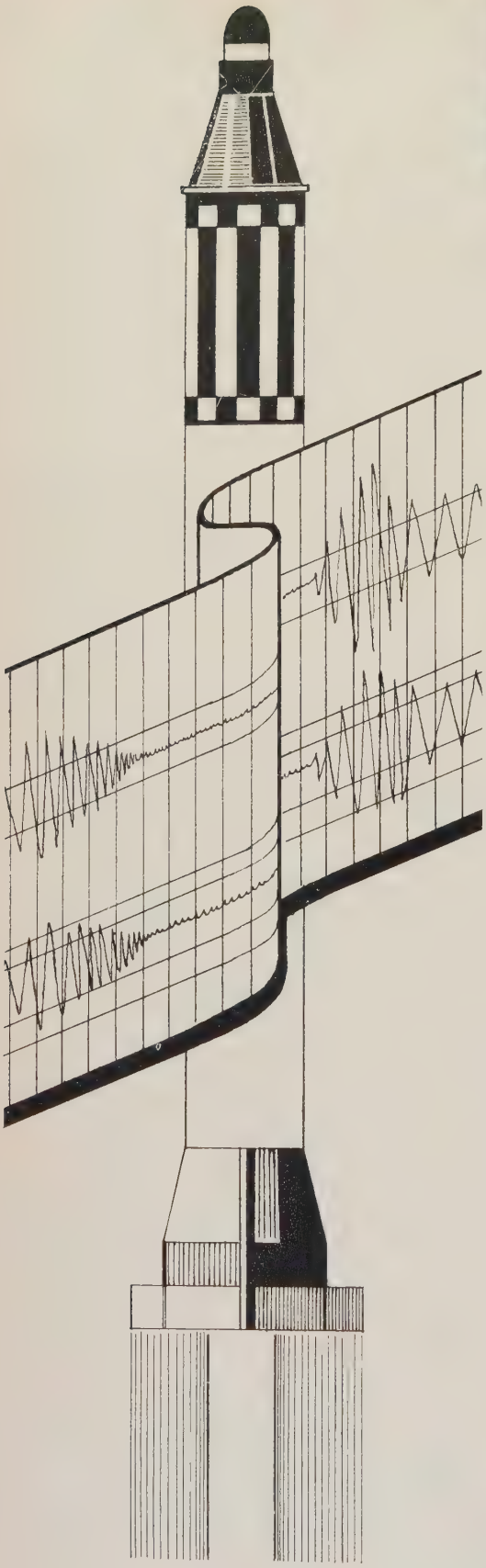
HOWELL INSTRUMENTS, INC.
FORMERLY B & H INSTRUMENT CO., INC.
3479 WEST VICKERY BOULEVARD • FORT WORTH 7, TEXAS

No. 120 on Reader Service Card



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when costs mount...
when the first try is it...

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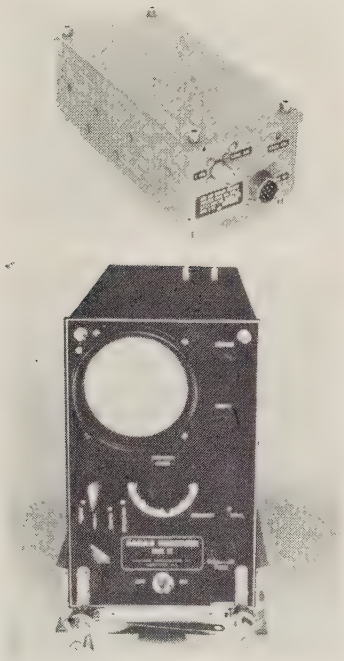
A DIVISION OF GENERAL ANILINE AND FILM CORPORATION

No. 121 on Reader Service Card

equipment preview

IV—Electronic Equipment



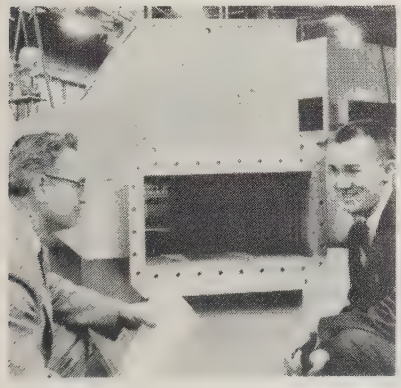
BEACON SYSTEM FOR CAPSULE RECOVERY USES CRT DISPLAY

The Sarah (*s*earch *a*nd *r*ecovery *a*nd *h*oming beacon system) is used in the location and retrieval of space capsules and missile nose cones. Produced by Simmonds Precision Products, Inc., Tarrytown, N. Y., it has been installed in every capsule of the Mercury program and has also been used successfully in the recovery of Nike-Cajon, Jupiter Atlas, Redstone, and Thor.

The system uses a miniaturized transmitting beacon (see *Photo*) that begins to transmit radio signals at a preset altitude when it is triggered by an explosive charge that also releases a coiled-up antenna. On the search craft, the signals are picked up by a pair of time-shared antennas and fed to a receiver having a CRT display (see *Photo*). The search craft homes in on the signal source by centering the received beacon signals on a vertical trace on the CRT.

A typical recovery sequence begins with the opening of the main recovery parachute at 10,000 ft, at which point the beacon begins to operate. The transmissions are coded pulses modulating a 243-mc carrier. The peak transmitted power of 15 W gives the beacon a ground-to-air range of about 70 miles and surface-to-ship range of about six miles. **89**

Waveguide Filters Suppress Radar Harmonics



To help eliminate the serious RFI problem caused by unwanted transmission from high power radar and microwave communications transmitters, Power Tube Dept., General Electric Co., Schenectady 5, N.Y., has designed a series of harmonic suppression filters. Seven of these filters, which normally fit in the waveguide between the RF output tube and the antenna, are available in the 400-6000-mc range. Filters for up to 10,000 mc are in development.

The filters absorb the unwanted harmonic power and dissipate it in the form of heat. In addition, they increase the fundamental power-handling ability in the waveguide transmission line by overcoming the waveguide breakdown problems likely to occur in equipment generating harmonic power.

• Ratings and dimensions of the seven available filters are:

• *MPF 2501*—pass band, 2.6-3.1 kmc; peak power, 5 Mw; stop bands, 4.8-6.2, 7.8-9.3, 10.4-12.4 kmc; dimensions, 3.6 in. by 9.6 in. diameter; weight: 50 lb.

• *MPF 2502*—pass band, 2.6-3.6 kmc; peak power, 5 Mw; stop bands, 6.0-7.2, 7.8-10.4 kmc; dimensions, 3.6 in. by 9.5 in. diameter; weight, 50 lb.

• *MPF-1001*—pass band, 1.2-1.4 kmc; peak power, 10 Mw; stop bands, 2.4-2.8, 3.6-4.2, 4.8-5.6, 6.7 kmc; dimensions, 51×24 in.; weight, 175 lb.

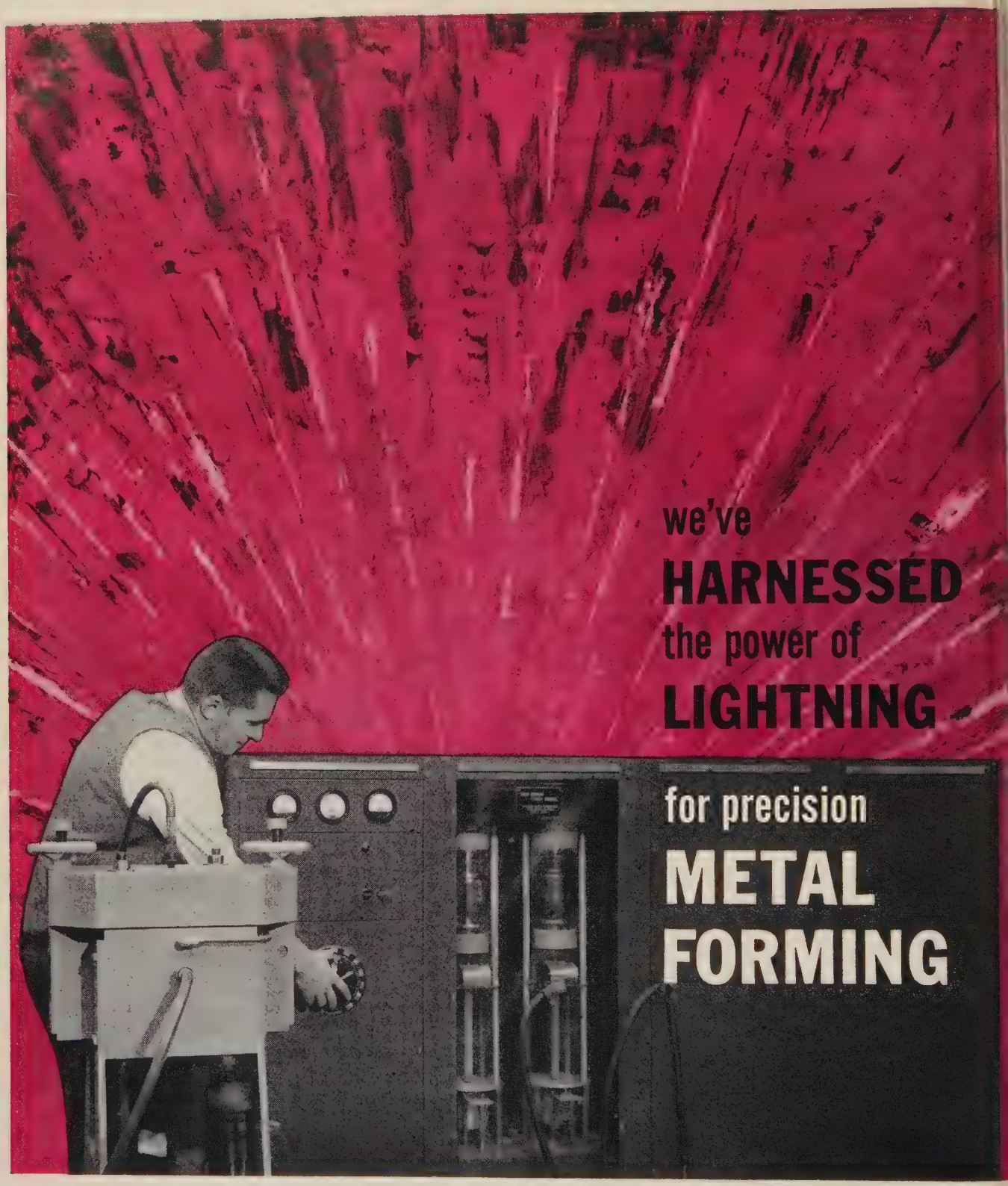
• *MPF-400*—pass band: 0.4-0.45 kmc; peak power, 5 Mw: stop bands: 0.8-0.9, 1.2-1.35, 1.6-1.8 kmc; dimensions, 166×49×34.5 in.; weight, 1200 lb.

• *MPF-4000*—pass band, 5-6 kmc; peak power, 1 Mw; stop bands, 10-12, 15-18 kmc; dimensions, 25 in. by 7 in. diameter; weight, 25 lb.

• *MPF-800*—pass band: 0.76-0.98 kmc; peak power, 0.1 Mw; stop bands, 1.51-1.97, 2.26-2.96 kmc; dimensions, 72×25×12 in.; weight, 250 lb.

• *MPF-2001* — pass band: 2.35-2.7 kmc; peak power, 20 Mw; stop bands: 4.7-5.4, 6.75-8.1, 9.4-10.8 kmc; dimensions, 48 in. by 15 in. diameter; weight, 100 lb. **68**

For details of equipment listed in this section, write in item number on Reader-Service Card



It's a reality at Rohr . . . an advanced electrical discharge forming technique that promises more speed and accuracy at far lower cost than other high energy forming methods. Releasing thousands of horsepower in millionths of a second through a high energy electrical arc, this Rohr unit has built-in safety elements allowing normal factory use. It forms steel, aluminum or "exotic" alloy parts of complex configurations in one quick operation. This new process, now in production use, and other techniques now in development, represent important technological advancements in a field where Rohr has excelled for years – finding faster, better, cheaper ways to form metals for our customers.

For information write: Mr. A. R. Campbell, Sales Manager, Dept. 52, Rohr Aircraft Corporation, Chula Vista, California.

Main Plant and Headquarters: Chula Vista, Calif. / Plant: Riverside, Calif. / Assembly Plants: Winder, Ga.; Auburn, Wash.

ROHR
AIRCRAFT CORPORATION

No. 122 on Reader Service Card

Voice Communications System for Carrier Decks

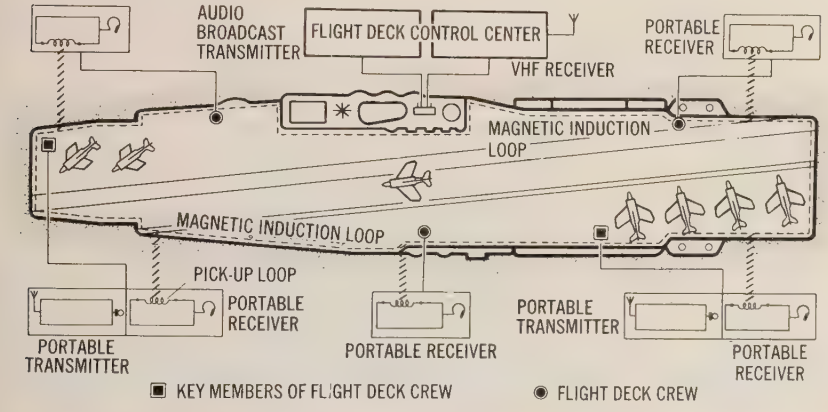
An inductive-loop system for voice communications between an aircraft carrier's island control center and flight-deck crews has been developed for the British Admiralty by Telecommunications Div., The Plessey Co., Ltd., Ilford, Essex, England. Normally direct voice communication on the flight deck is impossible because of the high noise level and the ear protectors worn by crew members.

Plessey's system lets the controller transmit orders over a broadcast channel at audio frequencies. The signals are fed into a magnetic coupling loop that encircles the carrier's flight deck and island. Crew members carry receivers that are sensitive to the AF-modulated magnetic field radiated by the coupling loop. The receiver amplifies and detects the voice signals and feeds them to an earphone built into the ear protector.

Key members of the flight deck crew have a low-power, fully transistorized VHF transmitter for deck-to-island control transmission. The transmitter is carried clipped to the audio receiver.

At the control center transmitter, the audio signals are mixed with AGC voltages and fed to a power amplifier whose output is transformer-coupled to the low-impedance deck-circling loop.

The "magnetic" receiver carried by the flight deck crews uses a potted ferrite coil to pick up the flux variations. After amplification, the audio is separated in a low-pass filter and fed to an output stage to drive the headset. The AGC signal is selected in a tuned amplifier, rectified, and applied to the receiver's first amplifier stage to regulate the overall gain. **70**



equipment in brief

FLUID CONNECTOR for electronic cooling use

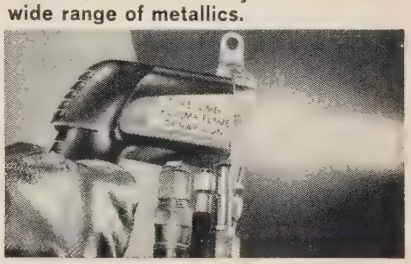
This miniature fluid connector can be used for electronic cooling, klystron cooling, magnetron cooling, electronic guidance packages, test stands, and instrumentation and sensing lines. As reported by the manufacturer, **E. B. Wiggins Oil Tool Co., Inc., Dept. S/A, 3424 East Olympic Blvd., Los Angeles 23, Calif.**, this 20 series model is available in size ¼ in. with ¼ in. ends, and features an automatic push-pull device for quick disconnect operations.

This one-ounce unit can reportedly withstand pressures up to 5000 psi and temperatures from —20 to +400 deg F. It is normally made of aluminum with Viton "A" seals, although stainless steel and various elastomers are available specially.

No. 180 on Reader Service Card

NOW—
Plasma flame sprayed coatings with precisely controlled characteristics

You can apply coatings of high melting point materials such as tungsten, alumina, zirconia, other refractory materials and a wide range of metallics.



New METCO Plasma Flame Spray System permits precision control of a wide range of coatings, and exact duplication of desired results.

Features of improved plasma flame spray system

GUN Nozzle and electrode positions fixed and foolproof. Nothing to adjust. Light for manual use; sturdy for machine mount. Compact: can operate inside 5" bore. Sprays up to 15 pounds per hour. Can be used with nitrogen, argon or helium, with simple nozzle change. 6-piece construction.

POWDER FEEDER Extremely accurate and consistent powder feed rates. Calibrated control permits exact duplication of coatings. Powder feeds without flutter, regardless of particle size, wear of parts, or amount in hopper. Operates at atmospheric pressure, refillable with gun in use. Hopper removable with twist of wrist; contains non-spill valve.

CONTROL UNIT Push button controls are mounted in modular design cabinet, with fail-safe features.

The new plasma spray system is 100% a METCO design, engineered for flame spraying only. Both METCO equipment and materials are backed by METCO's technical service in the field and at headquarters. For detailed information on the new equipment and unique characteristics of METCO materials, send for Plasma Bulletin No. 142.

METCO INC.
FORMERLY METALLIZING ENGINEERING CO., INC.
Flame Spray Equipment and Supplies

1133 Prospect Ave., Westbury, L. I., N. Y.
Telephone: Edgewood 4-1300 Cable METCO In Great Britain: METCO LTD., Chobham-near-Woking, England.

PLASMA FLAME sprayed coatings

METCO: Please send me free bulletin on METCO Plasma Flame Spray System.

Name
Title
Company
Address
City Zone State

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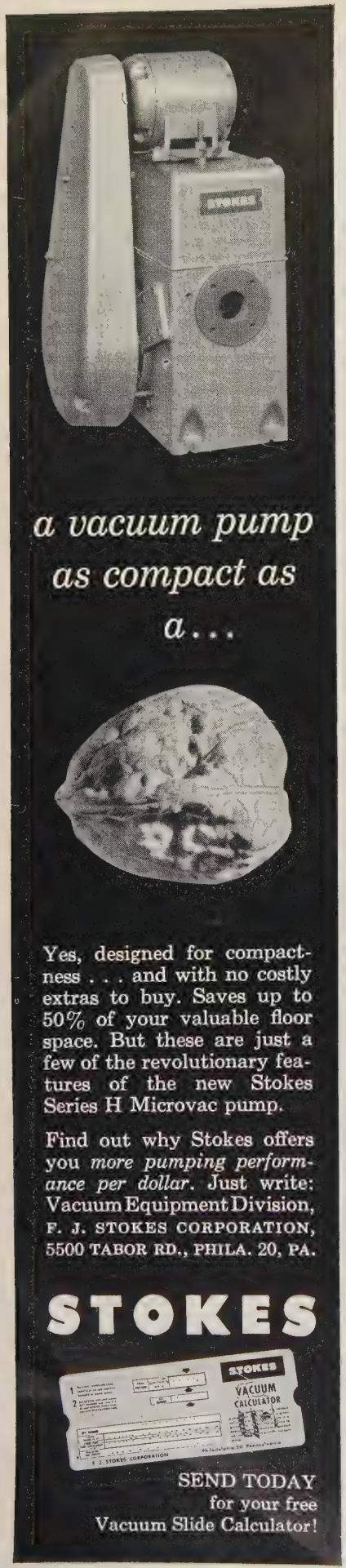
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a vacuum pump as compact as a . . .
Yes, designed for compactness . . . and with no costly extras to buy. Saves up to 50% of your valuable floor space. But these are just a few of the revolutionary features of the new Stokes Series H Microvac pump.
Find out why Stokes offers you more pumping performance per dollar. Just write: Vacuum Equipment Division, F. J. STOKES CORPORATION, 5500 TABOR RD., PHILA. 20, PA.
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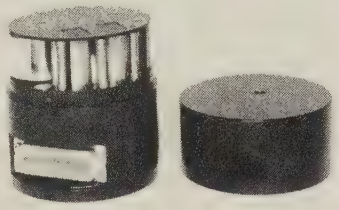
STOKES VACUUM CALCULATOR
SEND TODAY for your free Vacuum Slide Calculator!
No. 124 on Reader Service Card

MAGNETIC RECORDER for 1 to 14 channels



This miniature magnetic tape recorder simultaneously records data in 1 to 14 channels, in line or interlaced. It is available in speeds of 1.875, 3.75, 7.5 and 15 in. per second, with a capacity of 150 ft of 1 Mil Polyester Instrumentation Tape providing up to 16 minutes recording, says **Aero Data Mfg., Dept. S/A, 12780 B Western Ave., Garden Grove, Calif.** The unit measures 4¼ in. in diameter and 4¾ in. long. It weighs less than 3½ lb with full load of tape.

The wow and flutter under static conditions are said to be less than 1 per cent. All rotating shafts are supported by stainless steel ball bearings.

No. 253 on Reader Service Card

TINY THYRATRON TUBE for electronic uses

This WC-25 subminiature thyratron tube is for electronic, computer, and industrial applications. It is a size T2 glass bulb triode with a cold cathode, says **Electronic Industries, Inc., Dept. S/A, 18 Marshall St., S. Norwalk, Conn.** It consumes no power at standby and is triggered by 95 V dc.

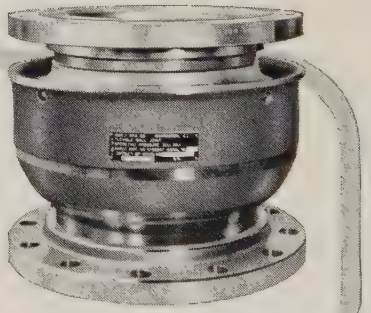
The triode is powered by an anode supply of 200 V dc at a resistance of 30 K ohms. Transfer current is 0.5 ma dc, maximum average. The tube contains radioactive material.

No. 254 on Reader Service Card

Y CIRCULATOR for microwave applications

This Y circulator was developed for low frequency high power operation in the VHF and UHF region, but is applicable up through the microwave region. The same unit can be used as an isolator and/or as a switch, according to **Electronic Communications, Inc., Research Div., Dept. S/A, 1830 York Rd., Timonium, Md.** The device can be used in relay links, radars, radio astronomy, reconnaissance radars, and battlefield surveillance.

No. 255 on Reader Service Card


NEW, lighter weight flexible BALL joints
SIZES: 3", 4", 6", 8", 10", 12"
for CRYOGENIC piping
FOR PROJECT REQUIREMENTS—In handling fluid fuels and oxidizers, including liquid oxygen. Also in industrial cryogenics for liquid methane and liquid propane or butane at low, as well as ambient, temperatures.
RECOMMENDED SERVICE—(1) Fluid loading arms. (2) Expansion Joints. (3) Gimbal/Rotary Swivel motion. (4) Shock resistant flexible piping.
NEW, ADVANCED DESIGN—Has passed official "Qualification Tests," including shock tests of more than 100G's. TEMPERATURES: −320°F to +275°F. PRESSURE RATING: Designed for and qualification tested at 200 psi operating, 300 psi proof, 700 psi burst pressures. *Ask for Bulletin 233 B.* BARCO MANUFACTURING CO., 575F Hough St., Barrington, Illinois.
1st for SAFETY
BARCO
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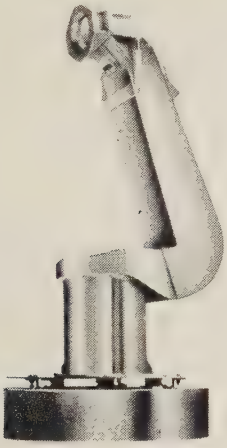
ANTENNA MOUNT positions array antenna



Designed for ground based or shipboard use, the model 11 antenna pedestal aid tracking servo system is reported to combine high performance, minimum weight, and low cost. In production at **Temec, Inc., Dept. S/A, Van Nuys, Calif.**, the mount enables placing the center mass of an array more closely on the axis of azimuth rotation. This arrangement is reported to minimize inertia, as well as the change in inertia, when the angle of elevation is changed, thus permitting greater accelerations.

The model 11 mount can accommodate antenna arrays up to 12 feet in height through angles of depression of as much as 15 deg. The mount is available in a slip-ring type where continuous azimuth rotations are required and non-slip-ring types for applications where continuous rotation is not required. This more economical version is capable of 900 deg of azimuth rotation.

No. 256 on Reader Service Card

DELAY LINES are modular

Modular type electromagnetic delay lines which may be gaged for printed circuit board applications by means of their internal construction, are now available from the **Gray & Kuhn Div., IMC Magnetics Corp., Dept. S/A, 6058 Walker Ave., Maywood, Calif.**

Designated as series DL-251, these units are constructed of non-nutrient, flame-retarding, plastic materials. Impedances range from 300 to 600 ohms with delay times of 0.1 to 0.8 ms. Delay time to rise time ratios of 10 to 1 are available, depending on unit impedance and size. Operating temperature range is —55 deg to +105 deg C.

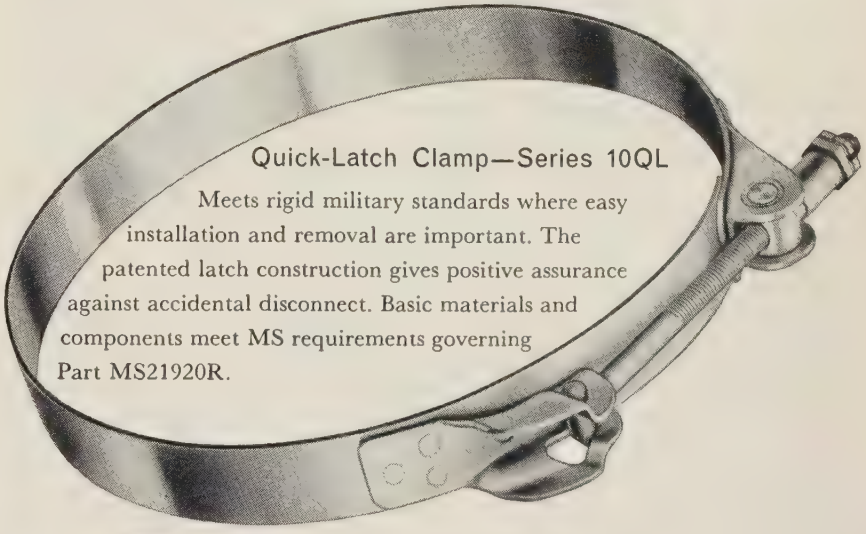
No. 257 on Reader Service Card

CLAMPS by WITTEK

for the *Space-Age*

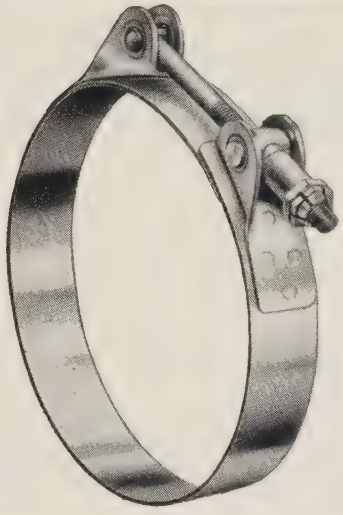
STAINLESS STEEL FLAT BAND CLAMPS

Complete range of sizes from 2¼" to 10" diameter



Quick-Latch Clamp—Series 10QL

Meets rigid military standards where easy installation and removal are important. The patented latch construction gives positive assurance against accidental disconnect. Basic materials and components meet MS requirements governing Part MS21920R.

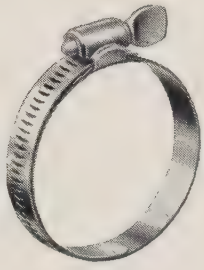


T-Bolt Clamp—Series 10T

Same as 10QL but without patented quick-latch, and recommended for more permanent applications. Meets MS requirements governing Part MS21920.

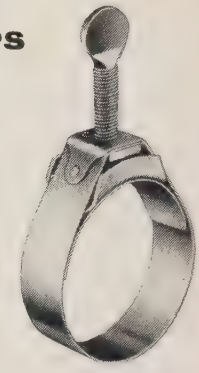
STAINLESS STEEL AIRCRAFT CLAMPS

Complete range of sizes



Type AN737-TW (with shoe)

Type AN737-TWLS (without shoe)



Type AN737-RM (floating bridge)

Descriptive literature or recommendations for any clamping requirements upon request.

Quality Clamps for over a Quarter Century

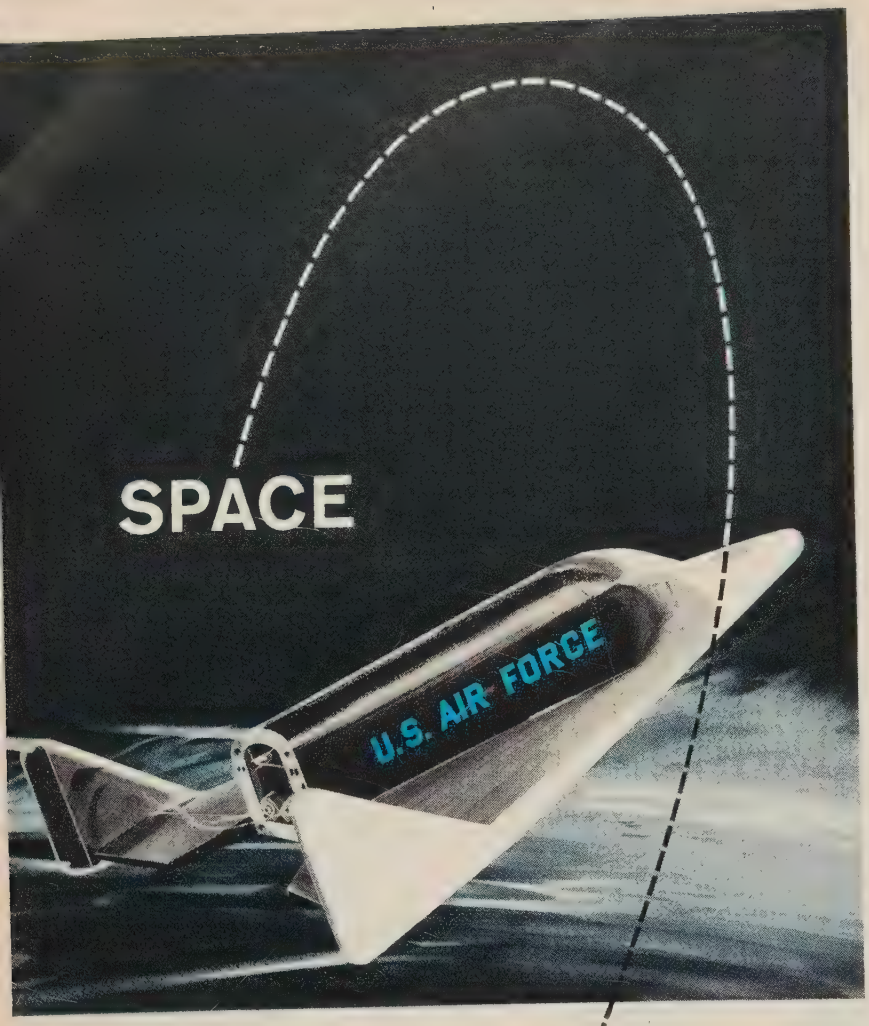
WITTEK MANUFACTURING CO.

4368 West 24th Place, Chicago 23, Illinois

CLAMPS for Every Application

BE25

No. 126 on Reader Service Card



TO BASE

With leading edges glowing from friction heat, the Air Force's Dyna-Soar manned space glider will make critical passage into earth's atmosphere.

Boosted into space by a modified Titan intercontinental ballistic missile, the Dyna-Soar will be left in piloted, near-orbital flight. At the pilot's choosing, he can glide into atmosphere to a conventional landing at an Air Force base.

To make it a safe flight, Boeing, system contractor for Dyna-Soar, is pre-testing all Dyna-Soar materials in accurately simulated space-to-base flight conditions. A Consolidated Vacuum test chamber reproduces the full environmental range—from atmosphere to as far out as 400 miles. This CVC chamber brings outer space down to earth . . . long before Dyna-Soar's first flight, Boeing engineers *know* what the spacecraft can withstand.

The same CVC capabilities are ready to provide complete turn-key facilities for *your* reliability testing program. Just check with the nearest CVC Sales Office, or the Custom Products Division, CVC, Rochester 3, N. Y.

Consolidated Vacuum Corporation

ROCHESTER 3, NEW YORK

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No. 127 on Reader Service Card

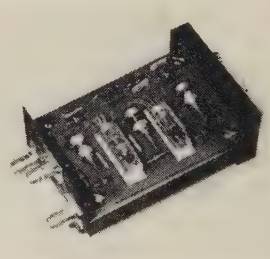
BAND ISOLATOR is miniaturized

This X band microwave isolator is smaller than former models and is said to provide high service characteristics.

Typical specifications for the unit are: frequency, FO ±50 MC; isolation, 15 db min; insertion loss, 0.3 db max; VSWR, 1.20 max; temperature ambient 0 to 50 deg C; average power, 1.0 watts, according to **Kearfott Microwave Div., General Precision, Inc., Dept. S/A, 14844 Oxnard St., Van Nuys, Calif.** Length of the isolator is one-half in.

No. 258 on Reader Service Card

MIXER-PREAMPLIFIER covers many frequencies



The "I" series of microwave mixer-preamplifiers is now available for operation from below 0.25 to above 17 kmc. The eleven models in this series each consist of either a coaxial or waveguide mixer together with a low-noise preamplifier, packaged in a single unit.

Orion Electronics Corp., Dept. S/A, 108 Columbus Ave., Tuckahoe, N.Y., says that each model can be obtained with either a single-ended or balanced input, symmetrical bandpass, and specified bandwidth, gain and noise figure. The voltage standing wave ratio for the signal and local oscillator inputs is from 1.2 to 2.2, depending on the frequency range and type of mixer selected.

No. 259 on Reader Service Card

MICROWAVE ANTENNA is portable

This microwave antenna is portable and designed for field use. It has handwheels for manual tracking in Azimuth and elevation, says **Automation Dynamics Corp., Dept. S/A, 255 County Rd., Tenafly, N.J.** This model is for tracking balloon radiosonde.

The instrument has parabolic antenna for operation at 1680 mc ±50 mc with gain of 22 db over half wavelength dipole and 10 deg beamwidth. Mount is available with parabolic, helical beams, and horn antennas.

No. 260 on Reader Service Card

GERMANIUM WINDOW SEAL for infrared detector

A recently developed technique for sealing germanium windows to infrared detectors now makes possible the fabrication of detectors for use in longer wavelength regions. The **Lansdale Div., Philco Corp., Dept. S/A, Lansdale, Penna.,** reports that the development enables detectors to receive transmission of infrared radiation beyond 25 microns, as compared with nine and six microns for silicon and sapphire windows.

In this new process, a glass frit mixed with amyl acetate is painted on the sealing surface of a germanium disc and then fused to another glass having comparable thermal coefficient of expansion. Philco states that the germanium seal has shown no signs of leaks at vacuum on 10^{-6} mm Hg. It is also reported to readily withstand thermal shock from ambient temperatures to liquid nitrogen and back to room temperature.

No. 261 on Reader Service Card

RECEIVER-TRANSMITTER for fast data transfer

Model MR-40 12-kmc microwave receiver-transmitter is reported to provide broadband communications which are well suited for very high speed data transfer. The unit also is well suited for transmission of conventional telephone and teletypewriter messages, according to **Motorola, Inc., Dept. S/A, 4501 W. Augusta Blvd., Chicago 51, Ill.**

This new package can carry data at 62,000 characters per second, or 20 times faster than the capacity of wire lines, says the company. The MR-40 unit provides 100 milliwatts of power output. Basic components include two reflex klystron tubes, each having a life expectancy of 20,000 hours of continuous operation.

No. 262 on Reader Service Card

OSCILLATOR tunable from 920 to 1400 mc

An L-band planar tube oscillator, tunable from 920 to 1400 megacycles, is now available from **General Communications Co., Dept. S/A, Boston, Mass.** The dual cavity with tuned plate and tuned cathode is controlled by a single leadscrew. The single dial control covers the entire range with relatively small change in output level.

Basic specifications of the unit are: operation—CW or pulse; power output—up to 50 watts; plate dissipation—5 watts max; backlash—less than 1 mc; filtering—all leads filtered for RF leakage; output connection—BNC connector.

No. 263 on Reader Service Card

LIMIT STOP UNIT used for programming

These 50-turn limit stop assemblies can be designed to furnish up to eight switch settings. The units are operated by a pushrod plunger assembly. The switches can be actuated to any position within the 50 turns, says **United Control Systems, Inc., Dept. S/A, 918 Woodley Road, Dayton 3, Ohio.** Accuracy is reported to be within ±5 degrees, or 0.027 per cent.

An anti-backlash device keeps mechanical accuracy high. The design also includes end position energy absorbing springs.

No. 264 on Reader Service Card

INFRARED DETECTOR has many uses

A new general purpose, low cost, lead sulphide detector is now available for industrial applications. This cell, available in quantity from **Tupper Trent Co., Inc., Dept. S/A, 207 Carter St., Chelsea 50, Mass.,** may be used for scanning, counting, sorting, machine-operator safeguards, liquid and bin control, signaling, switching, and ame-monitoring.

This very stable photoconductor has a nominal D* of 8x108, a mean time constant of 375 usec, and a dark resistance range from 500 K to 1.5 M. At normal room temperatures, the cell is sensitive to visible and intermediate infrared radiation over a range from 0.7 to 2.7 microns. The type FR-E47 cell is supplied mounted in a dual-prong plastic housing.

No. 265 on Reader Service Card

DISCRIMINATOR for stabilization systems

This discriminator is capable of furnishing an error signal with approximately forty times the stability of Klystron alone. The signal is available over the entire range of the discriminator, according to **Frequency Standards, Dept. S/A, P. O. Box 504, Asbury Park, N.J.** It is capable of accuracies of 0.01 per cent.

The effect of stabilization in the range of 8500-9600 mc is to reduce an inherent Klystron signal variation of 0.6 to ½ mc without stabilization to variations of 15 to 30 kc with stabilization.

No. 266 on Reader Service Card

CONSIDER THIS DIFFERENCE ✻ IN

Proportioning controls for metering electrical power

Nowhere will you find a proportioning control system that can surpass the performance of the new Barber-Colman silicon-controlled rectifier system with these features . . .

THE MARK OF QUALITY

BARBER COLMAN

- No filters—yet meets radio noise spec MIL-I-26600
- Power limiting—compensates for heater and windshield aging
- Anticipation circuit prevents too-rapid heating and cooling
- Fail safe on element failure
- For windshields, missile gyros, missile blankets, guidance compartments, and similar power metering applications.

✻ *In addition,* Barber-Colman provides a team of experienced engineers to custom-engineer a system to meet *your* specific needs . . . with personal, individualized approach. Also, you have complete factory service available on your equipment after installation. Isn't this the kind of experience, design assistance, and service you want on your projects? Consult the Barber-Colman engineering sales office nearest you: Baltimore, Boston, Dayton, Fort Worth, Los Angeles, Montreal, New York, Rockford, San Diego, Seattle, Winter Park, Fla., or write:

BARBER-COLMAN COMPANY

Aircraft and Missile Products Division
Dept. S, 1423 Rock St., Rockford, Illinois
No. 128 on Reader Service Card

LIVERMONT
TORQUE-LIMITING SCREWDRIVERS
FOR PRECISE TORQUE CONTROL

MODEL CAL-30

Model CAL-30 meets requirements of MIL-H-26497. Calibrations are clearly marked and magnified, for quick, easy reading. Disappearing thumb screw permits quick change of torque. (Torque setting can be sealed for production use.)

(capacity: 2 to 30 inch pounds)

MODEL PM-5

The Livermont PM-5 screwdriver is designed for electronic, and similar precision assembly work where extreme torque accuracy is required. Indicates for both left and right hand threads, and will accurately, safely, tighten the most fragile fastener, of metal or plastic.

NOTE: FAR EXCEEDS ACCURACY REQUIREMENTS OF MIL-H-26497

(capacity: 4 to 80 inch ounces)

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THERE IS A DEPENDABLE LIVERMONT TOOL

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871A

Improved FEL-PRO C5-A "HI-TEMP" ANTI-SEIZE THREAD COMPOUND

delivers MORE dollar value at same LOW COST!

All These New Improvements—
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NEW • Prevents rust and corrosion
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You'll save countless man hours and avoid costly replacement of broken studs, bolts, etc., with the protective cushioning action provided by the colloidal copper composition of C5-A. Improved C5-A Lubricates and Seals for fast, easy application and removal. Gives same protective performance even after high-pressure, high-temperature use, up to 1800° F. Can be used on all metals and plastics.

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✓ Ends seizing and galling even up to 1800° F.
✓ Reduces wrench torque
✓ Stops needless stud breakage
✓ Permits repeated re-use
✓ Speeds assembly and disassembly
✓ Prevents galling of stainless steel

TRY C5-A NOW . . .
You'll find it ideal for aircraft uses such as slip joints, manifold studs, turbo blowers, etc. Write for your free test sample today!

No. 130 on Reader Service Card

TAPE RECORDER used on missile

A new recorder, the MTR-800, designed for reliability of operation over a wide temperature range under extreme conditions of shock and vibration, is now in use on a U. S. missile. The device can be used to eliminate lapse of memory that birds develop in telemetry during re-entry, due to ionization, and in over-the-horizon transmissions, says **Leach Corp., Dept. S/A, 516 E. Compton Blvd., Compton, Calif.**

The MTR-800 has tape speeds of 0.25 ips to 60 ips, tape capacity of 300 ft of 1-mil Mylar, a maximum of three heads (incline or staggered per IRIG specs), a recording time of 60 sec at 60 ips—4 hr at 0.25 ips, 7 or 14 channels, a starting time of less than ½ sec, and a reversing time of less than 1 sec at 15 ips. Without shock mounting, the unit is rated for 15 g vibration at 5 to 2000 cps, acceleration of 200 g, and can withstand an impact of 1000 g.

No. 267 on Reader Service Card

SILICON MESA TRANSISTORS for small signal use

A full line of small signal silicon mesa transistors is now available for design engineers. The full line has just been announced by **Texas Instruments, Inc., Dept. S/A, P. O. Box 312, Dallas 21, Tex.**, and is specifically characterized for small signal use such as for audio and servo amplifiers, power supplies, and medium speed switches. The line includes the 2N734, 2N738, 2N1564, and 2N1572 series.

These new transistors facilitate design problems by offering a choice of TO-18 or TO-5 cases, 60- or 80-volt BV_{CEO} and betas of 20-50, 40-100, and 80-200. Beta is guaranteed at +25 and −55 deg C, at f = 30 mc, and $I_E = -1$ ma. Units in the TO-5 package have a power dissipation of 1200 mw at 25-deg case temperature and 600 mw in free air. TO-18 units have 1000 mw dissipation at 25-deg case temperature and 500 mw in free air, says the company.

No. 268 on Reader Service Card

DIGITAL DISPLAY DEVICE has shared matrix

By use of a unique shutter arrangement, a single diode-encoding matrix in the Digistrobe digital display is shared by all columns of the device. According to the **Kearfott Div., General Precision, Inc., Little Falls, N. J.**, this feature results in substantial savings in components and circuitry.

Specifications include a minimum strobe tube life of 2000 hours, 56 milliseconds maximum transition time from display quantity to display quantity, character height of 0.226 in., space between columns of ¼ in., and a viewing angle of 54 deg vertical and 90 deg horizontal. Applications include telemetry, airport traffic indicators, GCA monitoring, cockpit indicators, etc.

No. 269 on Reader Service Card

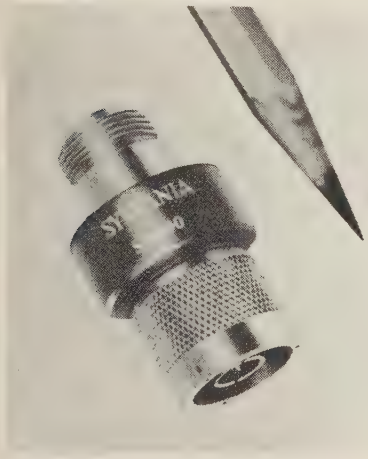
COAXIAL SWITCH for missiles

A coaxial switch that will take 50 g sustained acceleration and 20 g vibration from 75 to 200 cps has been developed for missile and space use, reports **Don-Lan Electronics, Inc., Dept. S/A, 1131 Olympic Blvd., Santa Monica, Calif.** The switch weighs 75 grams and features a switching time of 0.006 sec.

Switches are available in the line for 6 to 30 volts DC and 115-volt, 400-cycle AC operation. They can be operated with "TNC", "N", or "HN" coaxial connectors in an RF frequency range of 100 to 5000 mc.

No. 270 on Reader Service Card

MICROWAVE DEVICE improves sensitivity



A wideband microwave device that reportedly will simplify circuitry and improve the sensitivity of advanced microwave equipment has been announced by **Sylvania Electrics Prod. ucts, Inc., Dept. S/A, 500 Evelyn Ave., Mountain View, Calif.**

Designated the SB-100, the unit acts as a band-pass from 2.5 to 11,-000 mc, while isolating frequencies from DC to 2.5 MC. According to Sylvania, the new wideband low-1:ffi8 device will improve microwave sensitivity by eliminating 60-cycle ground loop currents and providing DC and low-frequency isolation in 50-ohm coax systems. At frequencies of 2.5 to 1,000 MC, insertion loss is reported to be 0.2 db or less. It is available with N, BMC, or TRN coax connectors.

No. 271 on Reader Service Card

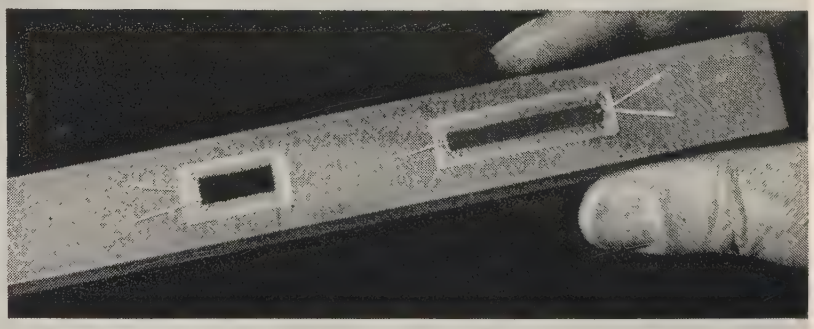
TUBULAR RELAY shock resistant

High vibration and shock resistance is reported in the series 123 tubular relay, which features unusual switching capacity and contact life, low coil power, small size, handy shape, and simplified mounting. According to **Wheelock Signals, Inc. Dept. S/A, Long Branch, N.J.,** the relay lends itself to in-line chassis mounting for printed circuits or conventional clamping or encapsulation.

Specifications are: contact rating—2 amps at 115 volts ac or 24 volts dc for 30,000 operations, 1 amp for 1,500,000 operations, and 3 milliamps for 50,000,000 operations; coil power —350 milliwatts at 25 deg C; vibration — 10 g to 2000 cps; shock — 30 g de-energized, 100 g energized; ambient — −65 to +85 deg C; life — 200,000,000 operations; coil resistance — 0.05 ohms max; operate time — 5 milliseconds; release time — 7 milliseconds; dropout — approx 30 per cent of pull-in; insulation resistance — 100,000 M at 25 deg C; dielectric strength — 750 volts rms.

No. 272 on Reader Service Card

BLH ADVANCES THE STRAIN GAGE ART WITH NEW WELDABLE, PRE-STABILIZED GAGES THAT INSTALL IN MINUTES



For the first time, strain gages that are both easily weldable and electrically stable from cryogenic through 750°F temperatures.

New BLH Weldable Strain Gages incorporate special SR-4® foil gages bonded to stainless steel shim stock .005 in. thick which can be matched to the coefficient of the test material. This new development enables gages to be closer to the test surface, improves conformity with the surface, and eliminates local buckling.

No curing needed after installation, because the gages are fully stabilized by heat treating. They offer high linearity of strain response in either tension or compression and operate in a strain range of ±0.5%.

Two types available—a phenolic-bonded Constantan foil for temperatures to 500°F, and a ceramic-bonded Nichrome V foil for temperatures to 750°F and higher. Temperature compensation is available to ±1 ppm/°F for units utilizing Constantan foil.

Wide range of applications is seen for testing nuclear reactor power loops, liquefied gas pressure vessels and systems, rocket and missile components and engines, and wind tunnel and shock chamber testing of aircraft parts.

Available locally through 16 BLH sales engineering representatives in the U.S. and Canada. For detailed information or assistance, contact the one nearest you—or us here in Waltham.

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FIRST in force measurement

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No. 131 on Reader Service Card

ENGINEERING

REPORT

ON BENDIX COMPONENTS

HOW MUCH CAN BENDIX SAVE YOU IN ANTENNA PEDESTALS?

GET OUR SPECIFIC ENGINEERING PROPOSAL

Bendix experience in ground radar pedestal design, manufacture and installation can benefit *you*. It can meet your requirements without delay. Since basic design and tooling have already been accomplished, modifications, for your prototype needs, can be made quickly—and with important savings—or, we can design a completely new pedestal to meet your specific needs.

Bendix ground-installation radar pedestals are lightweight, compact, air transportable. They possess a high degree of accuracy, and have been completely proved in the field. Bendix also is widely experienced in airborne radar systems for weather and target tracking purposes.

If these demonstrated radar capabilities meet your needs, write today for further information, including a *specific engineering proposal*. What are your requirements?

EXAMPLES OF APPLICATIONS:

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4-CHANNEL FILTER covers wide input range

A four-channel filter is now available with built-in video detectors designed to cover a very wide input dynamic range. Each channel has a bandpass of 2600-3200 mc at a maximum VSWR of 2:1, says **RS Electronics Corp., Dept. S/A, 435 Portage Ave., Palo Alto, Calif.**

The video detector in each channel has a tangential sensitivity of —40 dbm minimum. The dynamic range is obtained by using two 1N833 silicon diode detectors in parallel, one operating at full sensitivity, the second through a 14.5 db coupler. Filter dimensions are 6.15 in. diameter and 0.7 in. thick, excluding connectors.

No. 273 on Reader Service Card

COAXIAL COUPLERS provide flat coupling

A new line of high directivity broad band coaxial directional couplers, which provide flat coupling over a full octave frequency range with low VSWR, has been developed by **Narda Microwave Corp., Dept. S/A, 118-160 Herricks Rd., Mineola, N.Y.**

Directivity of the design exceeds 30 db. Coupling values of 10, 20, and 30 db are within 1 db of nominal value over the specified range, according to Narda. Calibration, marked permanently on the coupler, is said to provide accuracies of ± 0.2 db at five frequencies. The couplers may be used at lower than specified frequencies, with coupling increasing at approximately 6 db per octave, below the specified range.

No. 274 on Reader Service Card

FUNCTION GENERATOR solves complex problems

An analog function generator for multi-variable open or closed loop functions has been developed to solve complex simulation or control problems. Developed by the **Link Div., General Precision, Inc., Dept. S/A, Binghamton, N.Y.**, the unit uses a Link designed translatory servomotor, operated by a solid state servo amplifier, and a ceramic film resistance block which serves as an analog memory and interpolation element.

The function generator provides an overall system accuracy of better than 1 per cent and has a frequency response of more than 5 cps over full scale. Maximum resolution is 0.02 per cent. An important feature of the unit is the ability to expand the programing scale, thus furnishing high interpolation accuracy in areas with extensive irregularities.

No. 275 on Reader Service Card

No. 132 on Reader Service Card

SILICON TRIGISTOR features on-off control

A PNPN trigistor specifically designed for use in the 1-8 ma range is now available from **Solid State Products, Inc., Dept. S/A, 1 Pingree St., Salem, Mass.** The device features on-off control at a single base terminal, with drive requirements on the micro-ampere level.

No mounting insulation is required since all of the acting elements are isolated from the trigistor case. Long term reliability is reported enhanced by use of a cold-welded seal. Complete MIL-S-19500 environmental capability has been incorporated, says SSPI.

No. 276 on Reader Service Card

INFRARED DETECTOR for intermediate spectrum

An infrared detector cell, sensitive in the intermediate infrared spectrum, is reported to have high sensitivity and fast response. Developed by **ITT Laboratories, Dept. S/A, 3700 E. Pontiac St., Fort Wayne, Ind.**, these indium antimonide cells are reported ideally suited for use in search or track of aircraft and missiles.

To permit cooling to its operating temperature of 77 deg K, the sensitive element is mounted on the end of a cooling well which permits the use of either liquid nitrogen or a cryostat for operation with pressurized nitrogen. A wide range of cell resistances permits efficient coupling to either transistor or vacuum tube preamplifiers. The detectivity of these new cells, at 77 deg K, operating with a 500-deg K black-body radiation source, a 900-cps chopping frequency, and a 1-cps bandwidth, is in excess of 4×10^{-9}.

No. 277 on Reader Service Card

DISC MEMORY UNIT has low cross talk

A line of rotating magnetic memory units is now available from **Genesys, Dept. S/A, 1031 National Blvd., Los Angeles 34, Calif.** The units are available as computer components, test models, or console models. They are reported to have long life and reliability, as well as high pulse packing density and lowcross talk.

The UMM-3A model incorporates an 8-in. disc, a speed of 1800 rpm, 50 heads, write current of 30 to 60 ma peak-to-peak, readout voltage of 75 mv peak-to-peak, no dropouts, less than 15 per cent modulation pattern, capacity of 400,000 bits, and a life of over 5000 hours. Laboratory tests have indicated that special high density requirements can be met.

No. 278 on Reader Service Card

DELAY LINE is miniaturized

Delay line 2M1-5/5 is reported to achieve a 10 to 1 size and weight reduction over conventional delay lines, according to **Valor Instruments, Inc., Dept. S/A, 13214 Crenshaw, Gardena, Calif.** The high degree of miniaturization is accomplished by a network in which two coils are wound on each toroidal core, plus the use of temperature compensating ceramic disc capacitors.

The delay line has an attenuation of only 1 per cent (0.008 db) says Valor. This low insertion loss results from the use of subminiature toroidal inductors which enable relatively large values of inductance with extremely low dc resistance. The high Q of the inductive elements and capacitors yield very low losses. Total delay of model 2M1-5/5 is 0.2 microseconds; rise time is 0.04 microseconds; characteristic impedance is 500 ohms; temperature coefficient is 0.03 per cent per deg C.

No. 279 on Reader Service Card

MONOPULSE ANTENNA for system analysis

This monopulse antenna pattern simulator, in the 5.4 to 5.9 kmc range, will perform a checkout or system analysis on monopulse circuitry and computers. It is externally controlled and consists of waveguide and ferrite components, says **Rantec, Inc., Dept. S/A, Calabasas, Calif.** It simulates the signals normally derived from sum and difference circuitry by using an electronically driven microwave assembly.

The simulator provides adjustable electrical line lengths in both signal and local oscillator branches, and includes branching circuits with ferrite isolators and three balanced mixers.

No. 280 on Reader Service Card

POTENTIOMETER for small resistance changes

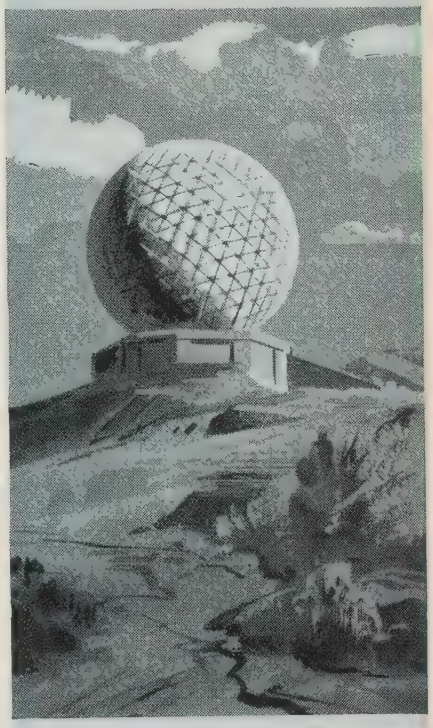
This deposited film precision potentiometer is for use where small increments of shaft rotation must produce proportionally small changes in resistance. It is said to provide resolution of better than 0.01 per cent, according to **Mechatrol Div., Servomechanisms, Inc., Dept. S/A, 1200 Prospect Ave., Westbury, L. I., N. Y.** The unit is manufactured in a high vacuum chamber using electron bombardment techniques.

This method provides a thin film metallic resistance element of extremely fine granularity capable of being resolved into infinitesimally small changes in resistance, the maker says. The unit measures 1 1/16 in. in diameter.

No. 281 on Reader Service Card

ENGINEERING REPORT ON OTHER BENDIX COMPONENT PACKAGES

PRECISION DATA AND CONTROL SYSTEMS FOR LARGE RADAR ANTENNAS



Through intensive research and development for major programs, Bendix offers a wealth of design experience in both digital and analog radar control and data systems. We can:

1 Develop *complete systems or subsystems* to comply with any customer requirement.

2 Provide a wide range of installation options, i.e.: one antenna or a battery; control of one radar by another; digital or analog control. Systems with accuracies of .005° or better can be offered.

Manufacturers of

GYROS • ROTATING COMPONENTS
RADAR DEVICES • INSTRUMENTATION
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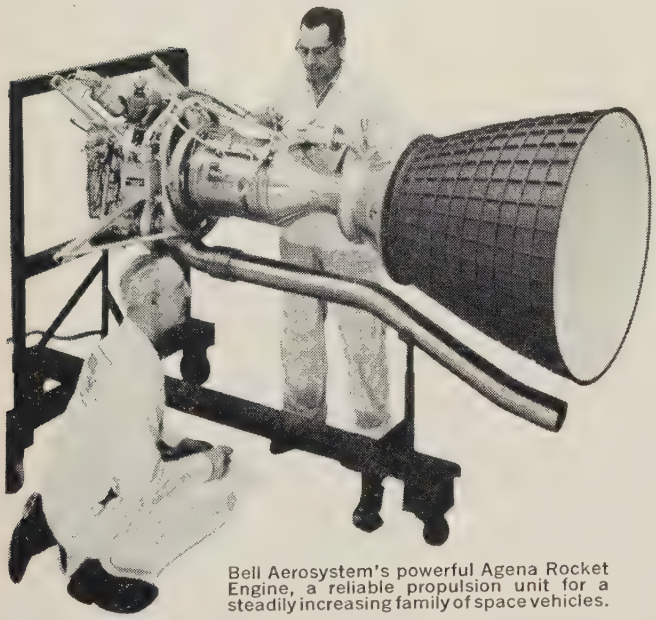
Eclipse-Pioneer Division

The Bendix Corporation

Teterboro, N. J.

No. 133 on Reader Service Card

Scheduled for the Moon ...and Beyond



Bell Aerosystem's powerful Agena Rocket Engine, a reliable propulsion unit for a steadily increasing family of space vehicles.

... with ROKIDE coating protecting the nozzle*

In the successful performances of the Agena Rocket Engine and other space propulsion units, Norton ROKIDE spray coatings have provided protection against the extreme temperatures and erosion of rocket blasts.

Used by many leading missile manufacturers and proved on many of today's space craft, ROKIDE "A" aluminum oxide and ROKIDE "Z" zirconium oxide provide maximum protection with minimum weight.

ROKIDE coatings, including special coatings for varying requirements, are available from Worcester, Mass., or Santa Clara, Calif. — or from licensed applicators in key cities. For further facts write to NORTON COMPANY, Refractories Division, 646 New Bond Street, Worcester, Massachusetts,

*Trade Mark Reg. U. S. Pat. Off. and Foreign Countries.

NORTON
REFRACTORIES
Crystallizing ideas into products

No. 134 on Reader Service Card

CATHODE RAY TUBE features fast writing

A single-beam, fast-writing cathode-ray tube having a 12 7/16-in. diameter face plate, has been announced by the **Allen B. DuMont Laboratories Div., Fairchild Camera and Instrument Corp., Dept. S/A, Clifton, N. J.**

Designated as type 12AMP, the electrostatic focus and deflection tube features a low drive electron gun which permits use of transistorized video circuitry. Post acceleration allows maximum deflection sensitivity with high overall accelerating voltages. Minimum spot defocusing is obtained, and the deflection plate connections are made through the neck of the tube to facilitate high frequency operation. The tube screen is aluminized for greater light output and to minimize screen charging effects.

No. 282 on Reader Service Card

GERMANIUM MESA TRANSISTORS feature low noise

This recent series of germanium mesa transistors for communications applications features low noise with an f max in excess of 1000 mc. These diffused base units provide ruggedness and reliability for use as rf amplifiers, oscillators, or if amplifiers says **Texas Instruments, Inc., Dept. S/A, P. O. Box 312, Dallas 21, Tex.**

The 2N1405, 2N1406, and 2N1407 transistors feature exceptional gain characteristics in the VHF/UHF range. Each device is reported to assure noise figures of 6 db, 8 db, and 10 db, respectively, at 200 mc. The 2N1405 series are recommended for mixer use. The 2N1405 and 2N1406 series are reported to be excellent for video amplifier circuits. The 2N1407 series is recommended for use in local oscillator circuits and for intermediate frequency amplifiers.

No. 283 on Reader Service Card

SOLID STATE RELAY is modular

A modular construction, solid-state relay, with a life in the order of millions of cycles is now available for delivery. According to the **Leach Corp., Dept. S/A, 5915 Avalon Blvd., Los Angeles 3, Calif.,** this model SR-101-1A static relay was designed for very high reliability requirements. The "layer cake" type construction allows quick adjustments for special purpose design in shorter lead time, according to Leach.

The relay operates at 30 volts DC, 60 ma. Operate time is approximately 10 microseconds; release time is about 50 microseconds. The relay is said to feature fast response, no contact bounce, contacts isolated from the control circuit, snap action switching with varying input voltage, and high shock and vibration resistance.

No. 284 on Reader Service Card

PLUG-IN CARDS simplify conversion

A series of transistorized plug-in cards is now available to implement large systems containing dynamic and static type digital logic, as well as analog computation sections. Designed by the **General Applied Science Laboratories, Inc., Dept. S/A, Merrick & Stewart Aves., Westbury, N. Y.,** the cards permit conversion from one type of computation system to another without the use of special circuits.

Six of the series of 15 cards are used primarily for static computing circuits; six other cards of the series are used to implement dynamic circuits systems. The remaining three cards can be used to implement a complete analog computing system or can feed a digital system through an analog-to-digital converter.

No. 285 on Reader Service Card

VOICE RECORDER has 22 channels

A 22-channel voice recorder has been developed for the FAA for use in traffic control centers. According to the **Electronics Div., Webcor, Inc., Dept. S/A, 816 N. Kedzie Ave., Chicago 51, Ill.**, the model 104-1 is fully automatic in operation and can be used continuously for 32 hours. It consists of two identical tape transports, each providing 16 hours of recording time on all 22 channels, with automatic transfer from one reel to the other. The 22 identical modular plug-in amplifiers are maintained easily, says Webcor. One plug-in provides for monitoring on any of the 22 channels. Each reel hold 4800 feet of magnetic tape.

In addition to the FAA use, other possible applications might include weather systems, communication recording, ship-to-shore, and others where storing of data is desirable.

No. 286 on Reader Service Card

DISCRIMINATOR is solid-state, small

This single-channel telemetry discriminator, type 42-7952, is completely solid-state and miniaturized. Its size is such that 18 units, covering the standard IRIG channels, mount on a relay rack panel 8¾ in. high, according to **Airpax Electronics, Inc., Dept. S/A, Fort Lauderdale, Fla.** Power requirements are 25 watts or less, 115 volts RMS, 60 CPS.

Input impedance is at least 43,000 ohms at all frequencies in range; output, ±1 volt DC into zero center, micro-ampere panel meter. Straight line deviation is ±0.25 per cent or better of bandwidth.

No. 287 on Reader Service Card

'VARIABLE' OVEN has high stability

This "constant temperature cavity" provides an oven for temperature compensation of diodes, crystals, and other electronic circuitry and components requiring stable temperature control. It is less than 4 in. high and about 1¼ in. in diameter, according to the **Electronics Div., Bulova Watch Co., Dept. S/A, 40-01 61st St., Woodside, 77, N. Y.** Designated model BG-200-4N, the unit is closely regulated by a hermetically sealed snap-action thermostat.

Among the variables available are temperature settings from 25 to 100 deg C, ±3 deg C; voltages from 6 to 117, ac or dc, 60 or 400 cycle; and heater power requirements of from 5 to 20 watts depending on warm-up time required and ambient temperature.

No. 288 on Reader Service Card

SOME TIMERS DO ALL THEY ARE DESIGNED FOR—AND MORE. Others just make claims. A.W. Haydon's record speaks for itself. Behind each: 101 "pros" pooling their timing technology...sophisticated test labs to assure peak performance ...built-in reliability reflecting years of experience. ■ A.W. Haydon makes them all: timing motors, time delay relays, elapsed time indicators and the like—electronic marvels from Culver City, electromechanical wonders from Waterbury. Shown: microminiature ETI—actual size. Literature on request. ■ If you need a reliable timing device—miniature for aircraft or microminiature for rocketry—remember, A. W. Haydon timers meet or exceed all MIL specs. When it's a matter of time, choose A.W. Haydon reliability.

PERFORMANCE OUTWEIGHS CLAIMS

THE AWH HAYDON COMPANY

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No. 135 on Reader Service Card

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An Example of
Synthane *You-shaped* Versatility

No matter how many laminated plastics parts you need, Synthane Corporation is the place to buy them. We're versatilely equipped to do the job—with hundreds of machines, designed especially for handling laminated plastics. Our people have years of experience in tackling any job in quantities from one to a million, in sizes large, small or in between, simple or complicated. This specialization results in complete control from manufacture of material to finished parts.

You-shaped Versatility makes Synthane a Better Buy in Laminates

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Synthane Corporation, 55 River Rd., Oaks, Pa.
Gentlemen:
Please send me information relating to Synthane as a source for laminated plastics materials and parts.

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Address_____

City_____ Zone____ State_____

No. 136 on Reader Service Card

shape of things to come

Tapes are now available from U. S. Radium to meet a wide range of data display applications. Open end or endless tapes of copper, stainless steel or Nylon—in lengths 40 feet and beyond—can be precision-marked by U. S. Radium.

Specially-developed paints in virtually any color are applied by exclusive screen marking techniques. Accuracy is guaranteed to ±.005 in. up to two feet. As lengths increase, accuracy decreases. Request additional information from our applications engineering group.

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MORRISTOWN, N. J.

Offices: Chicago, Illinois and North Hollywood, Calif. Subsidiaries: Radelin Ltd., Port Credit, Ont., Canada and U.S. Radium Corp. (Europe), Geneva, Switzerland.

No. 137 on Reader Service Card

data preview

I-materials & production equipment

BERYLLIUM COPPER — Beryllium copper strip products are the subject of a 12-page bulletin, No. S-1100-A, published by the **Beryllium Corp., Dept. S/A, P. O. Box 1462, Reading, Pa.** Five alloys are presented in tabular form with complete data on properties.

No. 289 on Reader Service Card

MODIFIED RUBBER—A 48-page technical manual on silicone modified rubber has been issued by **Stoner Rubber Co., Inc., Dept. S/A, 10792 Knott Ave., Anaheim, Calif.** It explains applications of rubber in the rocket and missile industry and includes various compounds, insulation data, and plastic laminates.

No. 290 on Reader Service Card

STEEL SHAPES — "Cast to Shape Steels" is the title of a folder of material data sheets prepared by **Vanadium-Alloys Steel Co., Dept. S/A, Latrobe, Pa.** In addition to general information, the bulletins provide temperature, curves, composition data, processing details, and other technical facts.

No. 291 on Reader Service Card

FACILITIES — Explosive forming and its facilities and development work in this field are discussed in a folder prepared by **Rocketdyne Div., North American Aviation, Inc., Dept. S/A, 6633 Canoga Ave., Canoga, Calif.** It is illustrated and lists applications and materials.

No. 292 on Reader Service Card

BOLT—A description and discussion of a bolt with built-in strain gage is contained in a 4-page bulletin available from **Strainsert Co., Dept. S/A, E. 4th St. Bridgeport, Pa.** Bulletin 361 provides mechanical and electrical specifications and other technical data.

No. 293 on Reader Service Card

FASTENERS — An 18-page brochure entitled "What you Should Know about Stand-off Fasteners" is available from **Western Sky Industries, Dept. S/A, 21301 Cloud Way, Hayward, Calif.** The illustrated publication contains specifications, line drawings, and technical data.

No. 294 on Reader Service Card

CAP SCREWS — Self-locking cap screws are discussed in a 4-page illustrated bulletin prepared by **Klincher Kapscrew, Inc., Dept. S/A, 2153 Hillside Ave., Indianapolis 18, Ind.** The bulletin is illustrated and provides detailed information on features and characteristics.

No. 295 on Reader Service Card

BONDING TECHNIQUES—Metalizing of ceramic parts is the subject of a bulletin issued by **Electronics Div., Globe-Union, Inc., Dept. S/A, 900 E. Keefe Ave., Milwaukee 1, Wis.** The bulletin describes the preliminary design and engineering considerations, and covers the properties and applications.

No. 296 on Reader Service Card

BLIND RIVETS—A six-page brochure providing information on blind rivets has been prepared by the **Cherry Rivet Div., Townsend Co., Dept. S/A, Box 2157-Z, Santa Ana, Calif.** The folder, TCL-166, includes a selection and procedure chart, specifications, as well as data on thicknesses, drill size, and rivet gun selection.

No. 297 on Reader Service Card

PLASTICS—Comparisons of the major properties offered by nine leading industrial plastics are summarized in graphic form in a 12-page report available from **Marbon Chemical Div., Borg-Warner Corp., Dept. S/A, Box 68, Washington, W. Va.** A cumulative properties comparison chart reveals the total performance value for each of the nine plastics.

No. 298 on Reader Service Card

WELDED STEEL TUBING — Welded steel tubing is the subject of a four-page illustrated brochure available from **Epps Industries, Inc., Dept. S/A, 2332 E. 32nd St., Los Angeles 58, Calif.** It includes a discussion of tolerances for both round and square tubing.

No. 299 on Reader Service Card

CARBORUNDUM—A pamphlet, "Materials for Advanced Technology", discussing research and development of a dozen products, has been prepared by the **Carborundum Co., Dept. S/A, P. O. Box 337, Niagara Falls, N. Y.** Properties and characteristics are presented in tables, and the publication includes thermal curves, as well as other technical information.

No. 300 on Reader Service Card

HARD CARBIDE—"E=94 x 10^6" is the title of a booklet that discusses hard cemented carbide. It is available from **Kennametal, Inc., Dept. S/A, Latrobe, Pa.** The 16-page, pocket-sized booklet provides information on qualities and characteristics and properties of hard carbide.

No. 301 on Reader Service Card

FIBERGLASS CASES — This 16-page booklet on hand portable cases is available from **Skydyne, Inc., Dept. S/A, River Rd., Port Jervis, N. Y.** The booklet contains price and size data on 22 standard size designs used to house optical electrical and electronic equipment in accordance with Mil-T-945A and Mil-Std-108C. It also contains data on modified and custom-built cases.

No. 302 on Reader Service Card

LUBRICANTS — References on more than 450 specifications in the fields of lubrication, hydraulics, corrosion prevention, and similar specialized areas are contained in a Mil-Spec Catalog published by **Bray Oil Co., Dept. S/A, 3344 Medford St., Los Angeles 63, Calif.** Also available is a list of ninety NATO symbols and the equivalent U. S. specifications.

No. 303 on Reader Service Card

THERMAL FABRIC — A product information sheet describing and discussing thermal barrier fabric is available from **Irvington Div., Minnesota Mining and Mfg. Co., Dept. S/A, Freehold, N.J.** It provides a table of typical properties and other technical data.

No. 304 on Reader Service Card

CHEMICAL CLEANING — A six-page pamphlet, "Chemical Cleaning for the Missile Industry," has been made available by **Dow Industrial Service, Dept. S/A, 20575 Center Ridge Rd., Cleveland 16, Ohio.** It describes the methods and importance of chemically cleaning the auxiliary equipment necessary to missile launching.

No. 305 on Reader Service Card

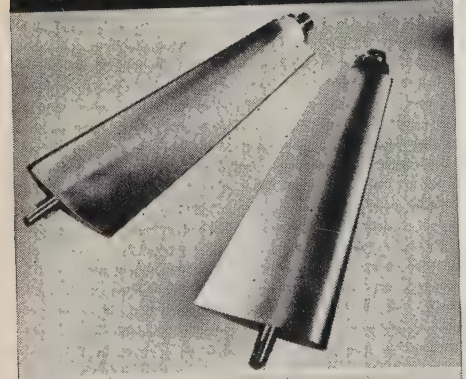
LAMINATED PLASTIC—A reference sheet on practical methods of machining Lamitex laminated plastics has been issued by **Franklin Fibre-Lamitex Corp., Dept. S/A, 129 Lafayette St., New York 13, N. Y.** It lists recommended speeds and feeds for circular or band sawing, turning and boring, threading, automatic screw machines, drilling, milling, gear cutting, and punching.

No. 306 on Reader Service Card

Stalker

lighter weight
lower cost
precision

SHEET METAL FABRICATIONS



Much time, effort and cost go into developing the processes necessary to produce satisfactory sheet metal fabrications. *The Stalker process has been PROVEN — with the production of many quality blades and vanes, as well as other brazed sheet metal assemblies.* Stalker Orthobrazed stainless steel or super-alloy fabrications — such as compressor and turbine blades — are *dimensionally and thermally stable.*

Produced to closer tolerances than the usual machined blades, nose radii of Stalker-produced blades feature a closer dimension and uniformity from blade to blade. The Stalker forming techniques also eliminate distortion during brazing and heat treat operations. Blades hold their precise shape because of the inherent thermal stability which insures Stalker quality. The Stalker quality control and inspection system is U.S.A.F. approved.

Stalker personnel, facilities and techniques are now available for the use of firms having precision sheet metal fabrication problems.

THE STALKER CORPORATION

Phone: Bay City — TWinbrook 3-7562
905 Woodside Avenue
Essexville, Michigan

No. 119 on Reader Service Card

DATA PREVIEW

THERMOCOUPLE WIRE—A 12-page catalog dealing with thermocouple wire and accessories has been published by **Claud S. Gordon Co., Dept. S/A, 3000 S. Wallace St., Chicago 16., Ill.** Bulletin 1-500 is illustrated and provides detailed information.

No. 307 on Reader Service Card

CERAMIC CEMENT—A special product note on ceramic cement has been published by **Trans-Sonics, Inc., Dept. S/A, P. O. Box 328, Lexington 73, Mass.** The bulletin on Type 64CP ceramic cement discusses its properties, applications, and characteristics.

No. 308 on Reader Service Card

II-accessory equipment

BRONZE BUSHINGS — A four-page folder dealing with bronze bushings has been issued by **Markey Bronze Bushing Co., Dept. S/A, Delta, Ohio.** The illustrated folder provides a table of the chemical composition and physical properties of brass and bronze alloys.

No. 309 on Reader Service Card

RELAYS — General purpose relays with contacts and terminals mounted in molded phenolic parts are discussed in Engineering Bulletin No. 1010 published by **Ohmite Mfg. Co., Dept. S/A, 3630 Howard St., Skokie, Ill.** It provides electrical, mechanical and physical data on the relay series.

No. 310 on Reader Service Card

OXYGEN SENSOR — A polarographic oxygen sensor is the subject of a 4-page illustrated folder available from **Beckman Instruments, Inc., Dept. S/A, 2500 Harbor Blvd., Fullerton, Calif.** It provides specifications, applications, and other general and technical information.

No. 311 on Reader Service Card

TUBE FITTINGS—Flareless tube fittings are the subject of a 4-page folder issued by **Parker Fittings & Hose Div., Parker-Hannifin Corp., Dept. S/A, 17325 Euclid Ave., Cleveland 12, Ohio.** Bulletin 4323B1 provides diagrams of shapes with nomenclature and size tables.

No. 312 on Reader Service Card

WELDED BELLOWS—An 8-page brochure presenting design and application data concerning welded diaphragm bellows has been published by **Metal Bellows Corp., Dept. S/A, 3010 Mica Lane, Wellesley Hills 82, Mass.** It offers updated information on the subject.

No. 313 on Reader Service Card

Torque Wrench Adapter

Calculator Slide Rule

Free

Instantly calculates scale conversion factors for adapters of different lever lengths—set it and read it.

Provides automatic selection of proper torque wrench for adapters and/or proper adapters to go with given torque wrenches.

Sent free upon request, compliments of

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TRIGGER QUICK

FINGER-TIP OR LANYARD RELEASE

FAST
EASY
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New Symetrics 500 Series Disconnects (3000 psi) offer these famous Symetrics features: Lightest weight . . . smallest envelope . . . zero leakage during disconnect . . . no air inclusion during connect . . . Full pressure and no exposed seals after disconnect . . . Unique design exceeds MIL-C-25427.

Other models available in plastic and special materials. For information on other Symflow Disconnects, write to:

SYMETRICS COUPLINGS

SYMETRICS, INC.
3100 AIRPORT AVENUE, SANTA MONICA, CALIF.

No. 139 on Reader Service Card

SPECIAL SEALS—Specialized seals for industrial, electronic, missile and high-performance aircraft applications are discussed in two bulletins issued by **Del Mfg., Dept. S/A, 1584 E. 20th St., Los Angeles 11, Calif.** One bulletin deals with high-pressure and extreme-temperature requirements; the other, with polymer seals for reciprocating and low-speed rotary shafts operating under high-pressure liquid and gas conditions.

No. 314 on Reader Service Card

RUPTURE DISKS — Impervious rupture disks, their various types and applications, are discussed in an 8-page catalog prepared by **Falls Industries, Inc., Dept. S/A, Solon, Ohio.** The bulletin deals with dimension standards, characteristics, venting capacities, gasket sizes, bolt torque specifications, and installation information.

No. 315 on Reader Service Card

MOTORPUMPS — Custom designed motorpumps for aircraft, missiles, and space craft are featured in an 8-page brochure available from **Vickers, Inc., Dept. S/A, P. O. Box 302, Detroit 32, Mich.** Bulletin A-5258 provides dimensional data and operating ranges. Photographs and installation drawings are included.

No. 316 on Reader Service Card

METAL-CASED SWITCHES — Complete details on metal-cased switches, including limit, safety, and aircraft products, are contained in Catalog No. 30-1 prepared by **Unimax Switch Div., W. L. Maxson Corp., Dept. S/A, Ives Rd., Wallingford, Conn.** A pictorial index shows location of dimension drawings, descriptions, force and movement specifications, and electrical ratings.

No. 317 on Reader Service Card

BLEED VALVE — A hydraulic bleed valve is the subject of a bulletin, Form 403, prepared by the **Weatherhead Co., Special Products Div., Dept. S/A, Cleveland 8, Ohio.** The bulletin contains engineering data, description, and other information.

No. 318 on Reader Service Card

INSTRUMENT MOTORS—An instrument motors and accessory equipment catalog is available from **Mechatrol Div., Servomechanisms, Inc., Dept. S/A, 1200 Prospect Ave., Westbury, L. I., N. Y.** Besides the RC610 catalog, the company has available literature dealing with digital stepper motors, metal film potentiometers, and MDA 59 Mechatronic Development Apparatus.

No. 319 on Reader Service Card

for space age performance reliability

MYSTIK BRAND

7503 Teflon, Silicone Tape

■ Here's the silicone pressure-sensitive tape you've been looking for! Backed with tough Teflon film (Du Pont's polytetrafluorethylene), No. 7503 tape measures a thin .006″ and provides excellent maneuverability in tight spaces. The silicone adhesive grips like a bulldog whether the temperature is —100°F. or +500°F. And No. 7503 tape offers an unusually high dielectric strength of 7,500 volts A.C. This Teflon tape is virtually impervious to liquid oxygen, acids, abrasion, water, solvents and aging ...and is completely reliable under the exacting conditions found in missile and space age electronic applications. Write today for the vital facts about Mystik No. 7503 pressure-sensitive Teflon, Silicone Tape.

Mystik Teflon Tape is available in a range of thicknesses.

MYSTIK TAPE® SELF-STIK

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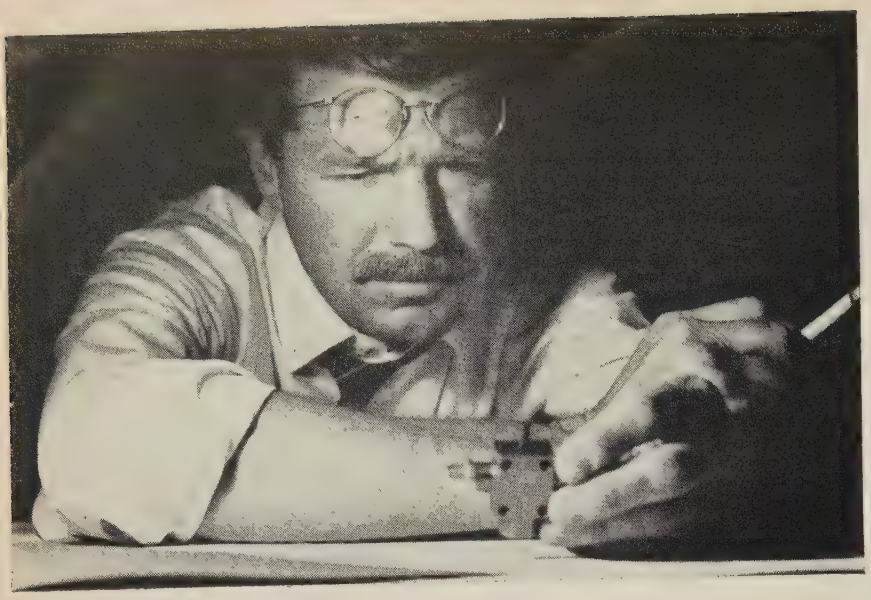
2635 N. KILDARE AVENUE • CHICAGO 39

No. 161 on Reader Service Card



MAJOR PROBLEM...in Propellant-Actuated Devices?

If your problem involves combining a sizeable force with light weight for positive, instantaneous operation, talk to Horkey-Moore Associates about propellant actuated devices. HMA has a wealth of experience in space vehicle applications, aircraft escape systems and ejectors for separation of airborne stores. Cartridge-actuated pin valves, pin pullers and other mechanisms can be used in many ways to accomplish a specific task. HMA's extensive facilities for engineering, manufacturing and testing are available. Call or write today.

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No. 162 on Reader Service Card

Name your service!

ALLOY STEEL SERIES
Working pressures to 10,000 psi.
316 STAINLESS SERIES
Working pressures to 6,000 psi.
416 STAINLESS SERIES
Working pressures to 10,000 psi.

...there's a MARSH NEEDLE VALVE for it

Three great series of needle throttling valves —designed and built as only Marsh experience *in both* valves *and* instruments can make them. In materials for extreme range of services. In a full range of sizes and patterns, including panel mounted. For a wide range of pressures and temperatures.

Body and stem guides machined from solid bar stock for extra strength. Precision ground stems with fine pitched stem-threads for close regulation—tight shut-off. Long lived, but easily replaced "Marpak" moulded packing; Teflon in stainless steel valves. Deep inlet and outlet threads for tight make-up.

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Division of Colorado Oil and Gas Corporation

Marsh Instrument & Valve Co. (Canada) Ltd., 8307 103rd St., Edmonton, Alberta, Canada. Houston Branch Plant 1121 Rockwell St., Sect. 15, Houston, Texas. Eastern Seaboard Warehouse: Marsh Instrument Company, 1209 Anderson Ave., Fort Lee, N.J.

Ask for bulletins covering full line

No. 163 on Reader Service Card

DATA PREVIEW

CONTROL SYSTEMS — Integrated control systems for aircraft and missile variable displacement hydraulic pumps are described in Bulletin A-5259 available from **Vickers Incorporated, Dept. S/A, P. O. Box 302, Detroit 32, Mich.** Curves illustrating typical regulation characteristics and specifications on both fixed angle and yoke type variable units are included.

No. 320 on Reader Service Card

HEAVY-DUTY SWITCHES — Heavy-duty, metal-cased snap-acting switches with sealed-plunger, roller-plunger, sealed-roller-plunger, and adjustable roller-level or hand actuators are described in Bulletin B-30 prepared by **Unimax Switch Div., W. L. Maxson Corp., Dept. S/A, Ives Rd., Wallingford, Conn.** Detailed descriptions and photographs show method of installing and structural details. Dimensioned drawings and force and movement specifications are tabulated.

No. 321 on Reader Service Card

III-testing & support equipment

TEST INSTRUMENTS—An illustrated catalog describing a line of instruments for high voltage testing of airborne electronic materials, components, and assemblies has been published by **Associated Research, Inc., Dept. S/A, 3777 W. Belmont Ave., Chicago,** Ill. The catalog, 10-1.3, offers detailed information on its range of products.

No. 322 on Reader Service Card

SERVO TESTING—Equipment for all phases of measurement of servovalves and servo systems, manufactured by the Industrial Measurements Corp., is described in a brochure obtainable from **John Jones Co., Inc., Dept. S/A, 445 N. Garey Ave., Pomona, Calif.** The instrumentation discussed is that designed for the static and dynamic evaluation of electro-hydraulic servovalves and servo system actuator packages.

No. 323 on Reader Service Card

LAUNCH FACILITIES — Launching sites, supporting facilities, and related information are discussed in a detailed 36-page brochure available from the **Department of Economic Development, Dept. S/A, State of Hawaii, 1124 Miller St., Honolulu 13, Hawaii.** The study deals with the potentials of Mauna Kea Island, covering topography, socio-economic facts, altitude, appropriate data. Title of the study is "Space Facility Capability."
weather, land suitability, and other

No. 324 on Reader Service Card

PRESSURE TESTING—Information on Bourdon Tube Gauges as test standards in the calibration of other instruments and in laboratory analysis is the subject of a 16-page illustrated brochure available from **Heise Bourdon Tube Co., Dept. S/A, Brook Road, Newtown, Conn.** The catalog deals with gauges for pressure ranges from 0-15 to 0-100,000 psi. It provides information on dial sizes, mounting dimensions, and related data.

No. 325 on Reader Service Card

THERMOCOUPLES—A 60-page catalog containing complete specifications and other information on thermocouples, pressure probes, and allied components is available from **Advanced Dynamics, Inc., Dept. S/A, 16321 Rockside Road, Cleveland 37, Ohio.**

No. 326 on Reader Service Card

VIBRATION EXCITERS—A technical discussion, entitled "Vibration Exciter Characteristics," by Jens T. Broch, Dipl. Ing. E. T. H. is the feature of the publication, *Technical Review*, published by **B & K Instruments, Inc., Dept. S/A, 3044 W. 106th St., Cleveland 11, Ohio.** The study delves into the whole subject of exciters, describing their characteristics, providing curves, charts, and diagrams regarding performance tests, and other technical data.

No. 327 on Reader Service Card

CRYOGENIC STORAGE – Cryogenic storage vessels are the subject of a 16-page brochure available from the **Chicago Bridge & Iron Co., Dept. S/A, 332 S. Michigan Ave., Chicago 4, Ill.** It is illustrated and presents curve charts and tables of technical data.

No. 328 on Reader Service Card

LIQUID MEASURE – "Liquid Measurements in Pounds" is the title of a detailed 16-page brochure, bulletin 522A, by the **Liquidometer Corp., Dept. S/A, Long Island City 1, N. Y.** It is illustrated and contains schematic drawings, calibration curves and other technical data.

No. 329 on Reader Service Card

GENERATING PLANTS – An entire line of gasoline and diesel driven electric generating plants is described and discussed in a catalog published by the **Onan Div., Studebaker-Packard Corp., Dept. S/A, 2515 University Ave., S. E., Minneapolis 14, Minn.** Form A-388 includes pictures of the outstanding features of each series, providing condensed specifications, details, and dimensions.

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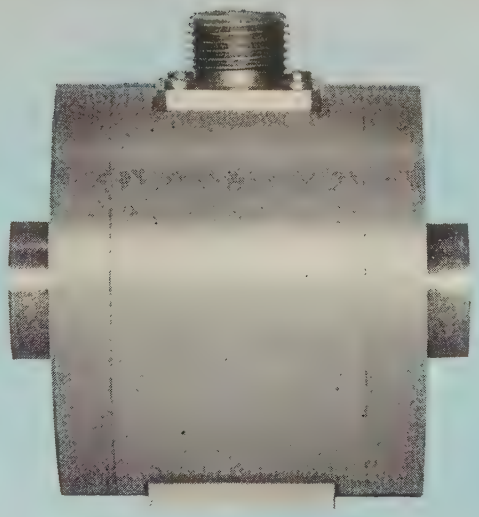

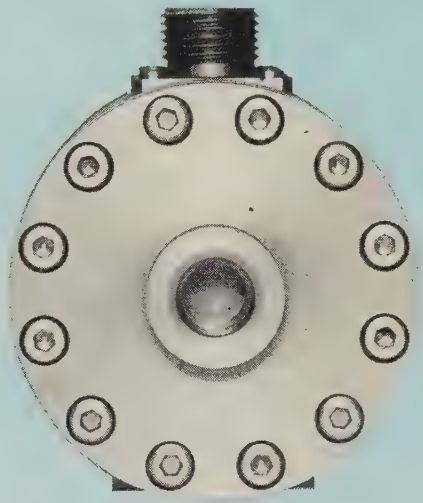

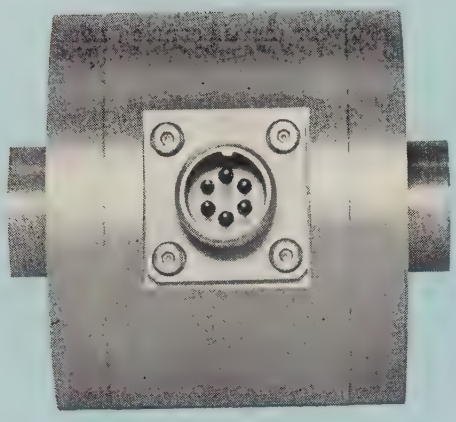

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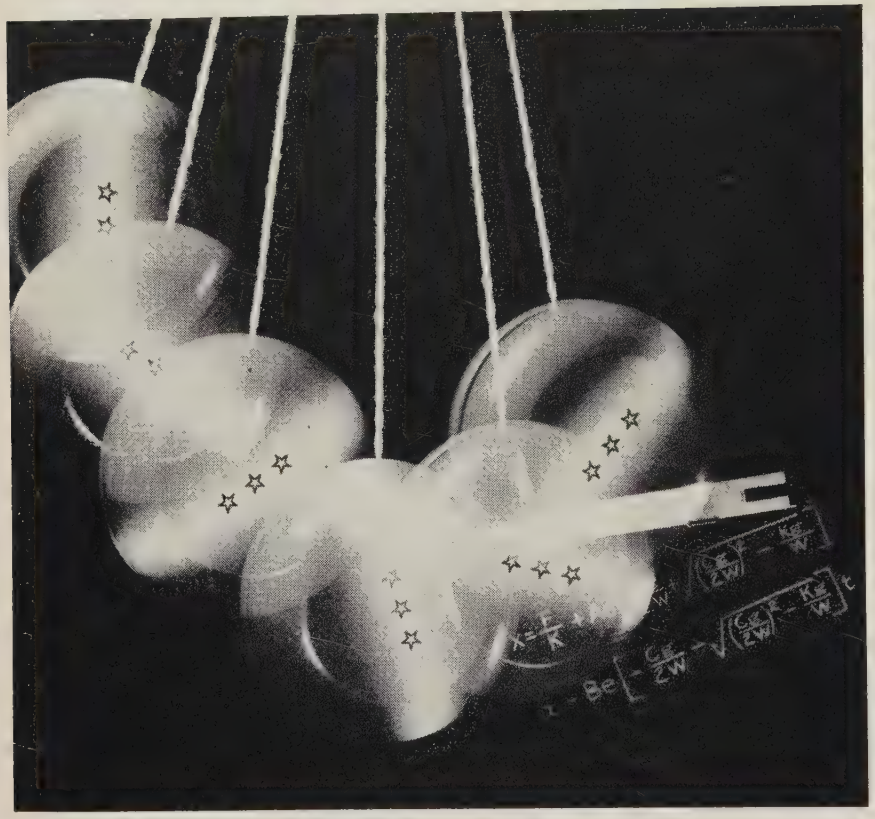

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DATA PREVIEW

GROUND SUPPORT AID — The facilities, products, and services of **Flight Support Div., Pacific Airmotive Corp., Dept. S/A, 11248 Playa Court, Culver City, Calif.** are described in a 6-page folder available from the company. It is illustrated.

No. 331 on Reader Service Card

SPACE SIMULATION—Space simulation facilities are described and discussed in Bulletin G-51 issued by **Chicago Bridge & Iron Co., Dept. S/A, 332 S. Michigan Ave., Chicago 4, Ill.** The illustrated folder provides diagrams and technical information.

No. 332 on Reader Service Card

TEST INSTRUMENTS — This catalog of a broad range of instruments for measuring, recording, and analyzing vibration and strain has been prepared by the **Instruments and Acoustics Div., The Korfund Co., Inc., Dept. S/A, 78 E. Cantiague Rd., Westbury, N. Y.** It contains photos, data charts, and specifications on vibration transducers and exciters, strain gages, load cells and beams, engine monitoring units, and readout devices.

No. 333 on Reader Service Card

IV-electronic equipment

SOLID STATE RELAY—A solid state "static" relay is discussed in a data sheet issued by **Leach Corp., Dept. S/A, 18435 Susana Rd., Compton, Calif.** It provides technical specifications and a functional diagram.

No. 334 on Reader Service Card

TRANSDUCER SYSTEMS—A series of articles on varied applications of transducer systems has been collected and released by **Gilmore Industries, Inc., Dept. S/A, 13015 Woodland Ave., Cleveland 20, Ohio.** Included in Bulletin TD-105 are such subjects as electronic weight loading of hot metal, electronic weight, force and thrust, strain gage testing, calibration of transducers, and temperature testing.

No. 335 on Reader Service Card

ACCELEROMETER-AMPLIFIER — A technical bulletin containing specifications on accelerometer-amplifier system Model 50x2 is available from **Columbia Research Laboratories, Dept. S/A, MacDade Blvd. & Bullens Lane, Woodlyn, Penna.** This solid state system, which measures missile shock and vibration data, weighs about 4 oz.

No. 336 on Reader Service Card

RELAYS – General information, specifications, and illustrations of general purpose relays are contained in Bulletin GC-100 prepared by **Artisan Electronics Corp., Dept. S/A, 171 Ridgedale Ave., Morristown, N. J.** The folder also offers curve charts on continuous and actuator duty.

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TELEMETRY SWITCH – A six-page technical bulletin describing a microminiature telemetry switch has been published by **Electro-Tec Corp., Dept., S/A, 10 Romanelli Ave., S. Hackensack, N. J.** The bulletin, 10S, provides design features, operating characteristics and environmental performance, dimensions, graphs, and diagrams.

No. 338 on Reader Service Card

V-capabilities

FACILITIES—The research and development, design and manufacturing facilities of the company are described in an 8-page brochure available from **Bart Mfg. Co., Dept. S/A, 125 Manchester Pl., Newark 4, N. J.** The publication is illustrated.

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CONTROL INSTRUMENTS—Describing its services, facilities and products, **Consolidated Diesel Electric Corp., Dept. S/A, 880 Canal St., Stamford, Conn.,** has published an illustrated 8-page folder. It lists the various products available from each of CONDEC's subsidiary companies.

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FACILITIES – Information regarding its research, development, production, and field and technical data services is provided in a 20-page brochure issued by **Singer-Bridgeport, Dept. S/A, 915 Pembroke St., Bridgeport 8, Conn.** It describes physical equipment and facilities for prototype fabrications, as well as production resources for mechanical, electro-mechanical and electronics components, assemblies and systems.

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FACILITIES—The products and facilities of **Precision Circuits, Inc., Dept. S/A, 85 Weyman Ave., New Rochelle, N. Y.,** are described in an 8-page brochure. It also covers the company's R&D work in the field of electronic component microminiaturization. Also described is Molecular Electronics, Inc., a subsidiary which manufacturers semiconductor test equipment for research, quality control, and production.

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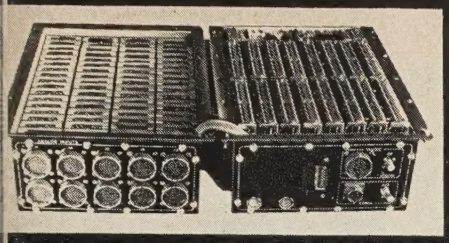

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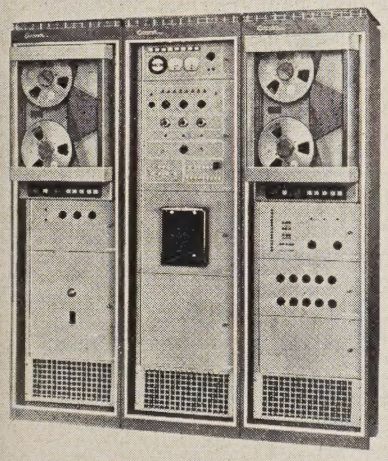

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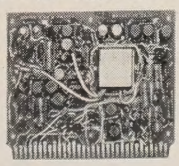

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BOOKS

Introduction to Underwater Acoustics: Reads Well but Lacks Some Detail

Underwater Acoustics Handbook
By Vernon M. Albers

WRITTEN ON a semi-technical level and in a very understandable manner, this book should be valuable to readers who are just getting into underwater acoustics or want an easily digested survey of the many facets of this field. Though no rigorous derivations of formulas are presented, a general technical background is helpful for a full understanding of the material that is presented. Much of this material is covered in considerably greater detail in Horton's Fundamentals of Sonar—which is not nearly as readable as this book, however.

The author begins with a defintion of sound and a description of underwater sound transmission, a discussion of units and reference standards, and a review of the physical characteristics of the sea as they affect underwater acoustics. He touches only lightly on each of these subjects (some of which are treated again at greater length in later parts of the book). Remarkably enough, nowhere in the discussion of units of measurement nor in any other part of the book is there any mention of the microbar, although this pressure unit is used in much of the current literature on underwater acoustics.

In his review of the medium, the author covers the various factors that inhibit the propagation and reception of acoustic energy in the sea. The technical level of the book increases somewhat in the chapters on discontinuities and inhomogeneities, ambient noise, and reverberation. The first of these three chapters is notable for its clear discussion of underwater air bubbles and their effects on acoustic transmission, while the one on reverberation summarizes fairly effectively the unclassified information on this subject. (Tables of bottom-scattering and volume-scattering coefficients are included.)

The author then goes on to deal with transducers, the noise generated by ships, torpedoes, and snapping shrimp, artificial acoustic targets, and methods of determining the origin of acoustic energy impinging on hydraphones. The material on transducers is generally theoretical and does not go far enough into the actual design problems. The chapter on the noise caused by ships and torpedoes is very sketchy and contains no graphs or charts. The last part of the book is concerned with techniques of acoustic measurement.

Generally there is a lack of information on low-frequency acoustics (below one kilocycle). Even more serious is the absence of a bibliography. References are listed throughout the book, but they are all rather old—the most recent date from 1955.

WILLIAM P. ZAKOWICZ
Avionics Systems Engineer
ASW Section
Douglas Aircraft Co.

Books in Brief

ADVANCES IN THE ASTRONAUTICAL SCIENCES: *Proceedings of the Sixth Annual Meeting of AAS—'60. By H. Jacobs and Eric Burgess (ed.). Macmillan. $25.*

ADVANCES IN CRYOGENIC ENGINEERING, VOL. VI. *By K. D. Timmerhaus (ed.). Plenum Press, $15.*

OXIDATION OF TUNGSTEN AND TUNGSTEN BASED ALLOYS (WADC TR 59-575). *By E. A. Gulbransen et. al. $2.25.*

DESIGN FUNDAMENTALS OF ANALOG COMPUTER COMPONENTS. *By R. M. Howe. Van Nostrand. $7.50.*

ATLAS OF THE OTHER SIDE OF THE MOON. *Pergamon. $7.*

SOLID PROPELLANT ROCKET RESEARCH. *By Martin Summerfield (ed.). Academic Press.*

STANDARDS OF THE ALUMINA CERAMIC MANUFACTURERS ASSOCIATION. *Alumna Ceramic Manufacturers Assn. $1.*

U. S. MISSILES AND SPACECRAFT: *Review of Achievements in 1960. National Aviation Education Council, Washington 1, D. C. $1.50.*

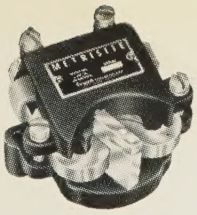
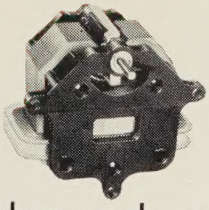
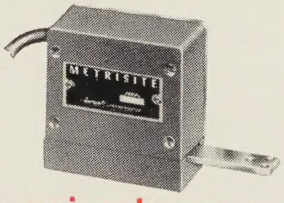
HIGH STRENGTH STEELS FOR THE MISSILE INDUSTRY. *By H. T. Sumsion (ed.). Society for Metals, Novelty, Ohio. $12.*

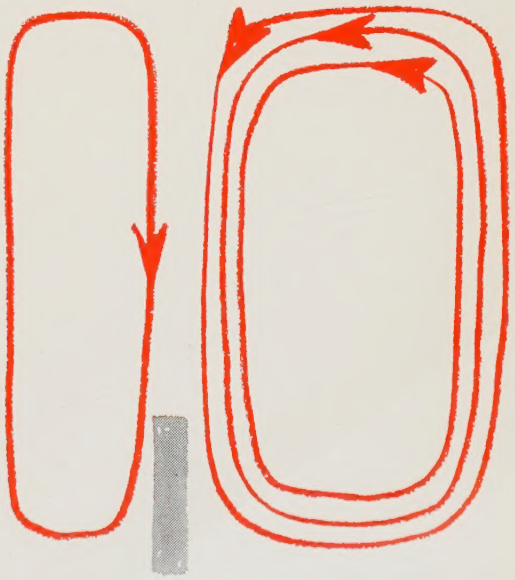
ONR SYMPOSIUM ON SUPERCONDUCTIVE TECHNIQUES FOR COMPUTING SYSTEMS, MAY '60 (PB 161763). *OTS. $4.50.*

MISSILE CONFIGURATION DESIGN. *By S. S. Chin. McGraw-Hill. $11.*

PRINCIPLES OF INERTIAL NAVIGATION. *By C. J. Savant, R. C. Howard, C. B. Solloway, C. A. Savant. McGraw-Hill. $9.75.*

ENERGY THEOREMS AND STRUCTURAL ANALYSIS. *By A. H. Argyris, S. Kelsey. Butterworth, Washington, D. C. $4.*

Metrisite... is the only  device available today that  provides a near-perfect combination of ideal transducer characteristics. The unusual properties of this remarkable new motion-sensing development are: extreme resolution...  easily measures one ten-millionth of an inch; minute operating force... absolute minimum bearing friction; negligible reactive force... a fraction of a milligram; true linearity... a proven accuracy of 1/10%; high electrical output... up to 100 volts without amplification; wide range of shapes and sizes... from sub-miniature on up; exceptional ruggedness... can meet military shock and vibration tests. Now, many of the obstacles that have plagued control technology can be eliminated. Write for Metrisite details.



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